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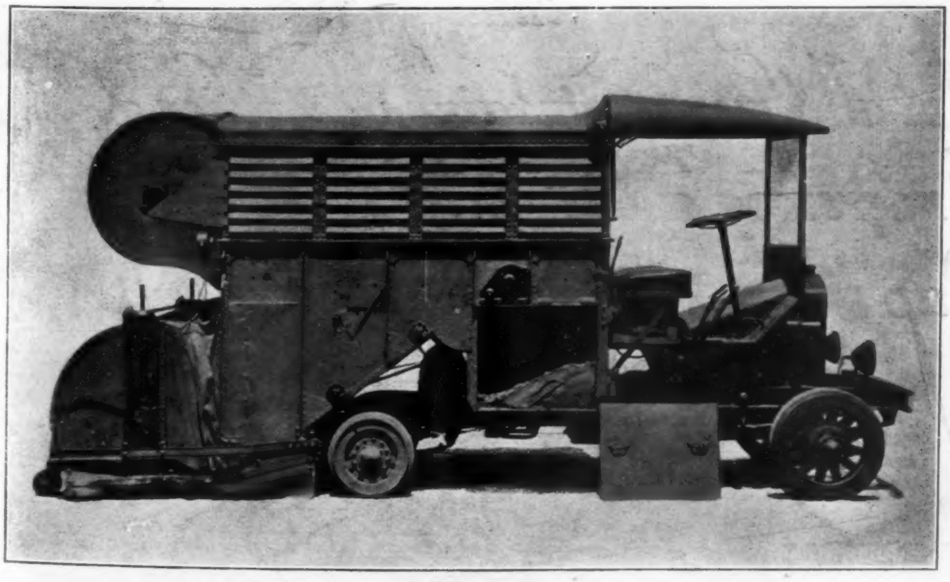

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PUBLIC WORKS.

CITY COUNTY STATE

A Combination of "MUNICIPAL JOURNAL" and "CONTRACTING"

Vol. 54 September, 1923 No. 9

Improving Wilmington's Water Supply

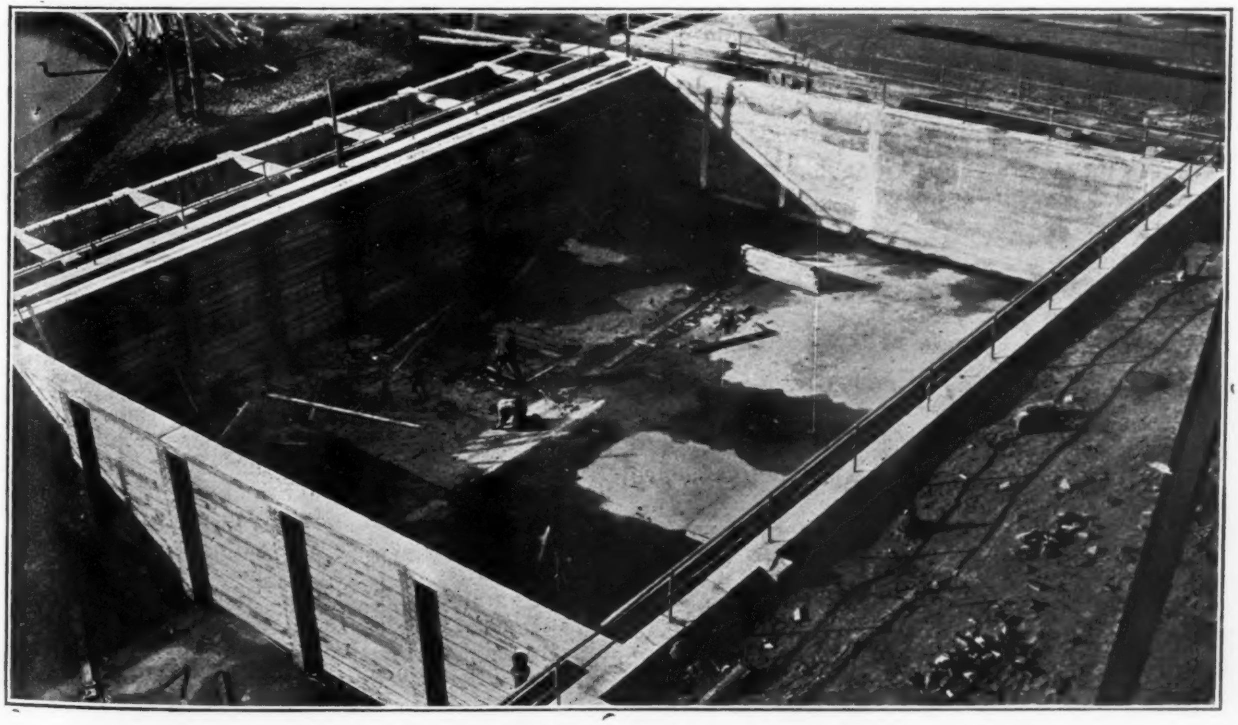
By C. W. Smedberg*

Changes in and enlargement of purification plant, relocation of intake, and installation of motor-driven pumping plant, result in furnishing a water of more reliable quality at a reduction in operating cost sufficient to pay for the improvements.

The city of Wilmington, N. C., during 1922 made extensive improvements to its water supply involving an expenditure of more than a quarter of a million dollars. They included providing a new source of supply and intake line, overhauling the filter plant and building a new filter basin and reconstructing the coagulating basin, and installing dry-feed machines and motor-driven centrifugal pumps on the high-pressure system.

The plant is a municipal one, acquired by purchase from a private company in 1909. It was enlarged in 1910 and again in 1919, there then being twelve 500,000-gallons-per-day filter units, a clear-water well of 160,000-gallons capacity, three coagulating basins and a 1-1/2-million-

*Sanitary Engineer, Carolina Engineering Company, Wilmington, North Carolina.



RECONSTRUCTING COAGULATING BASIN.
Showing uncompleted mixing chamber, entrance diffusion wall, dividing wall, overflows and outlet weir.

TOOMER'S CREEK INTAKE STATION AND SUBMERGED SUCTION PIPE.

gallon storage reservoir, together with a pumping station.

The source of the supply was the northeast branch of the Cape Fear river, on the east bank of which is located the pumping station and filtration plant. This stream carries the flow of numerous small creeks that originate in swampy lowlands and has a high color and relatively low turbidity. It is affected by the tide, which has an average variation here of 3 feet, resulting in a change of the quality of the water with each tide.

With the growth of the city and of the sewerage system, outlets were constructed emptying into the river below the intake, following which the amount of sewage backed up to the intake by the tide has increased. It was found necessary to pump all of the sewage from one section of the city to a point below the intake, which pumping involved considerable expense, and some trouble has been experienced in maintaining the pumping station in continuous operation, and very frequently raw sewage has reached the intake. Table No. 1 gives analyses of the old supply averaged for three years and indicates the heavy load placed on the plant. This condition, combined with the deterioration of the filter plant, resulted in the safety of the water supply becoming more or less questionable, while during periods of severe drought salt water has backed up into the intake, although this is located thirty miles from the ocean. A realization of these objectionable features was the cause of making the improvements above referred to.

Table No. 1
Analytical Data Northeast Branch Cape Fear Averaged over period of Three Years

Year	Color	Turbidity	Alkalinity	Co	Cl	Total Hardness	Permanent Hardness	Bacteria per c.c. at 20° C.	Bacteria per c.c at 37° C.	B Coli Index per 100 c. c.
1920	133	94	8	8	21	21	13	..	999	530*
1921	161	48	11	8	155	37	26	2972	3085	3255
1922	160	33	10	6	15	8	1	1781	1333	2712
Ave.	151	58	10	7	64	22	13	2376	1806	2166

*Dilutions to 0.10 c.c. only.

Table No 2
Analytical Data Toomer's Creek Water (Compiled from Report of G. F. Catlett)

High Tide

	Color	Turbid.	Alk.	Bacteria per c.c.	B. Coli 10	B. Coli 1	B. Coli 0.1
Maximum	110	65	25	400	+	0	0
Minimum	72	22	16	29	0	0	0
Average	86	38	21	166	59%	0	0

Low Tide

	Color	Turbid.	Alk.	Bacteria per c.c.	B. Coli 10	B. Coli 1	B. Coli 0.1
Maximum	100	45	28	450	+	0	0
Minimum	78	17	18	48	0	0	0
Average	86	29	22	214	60%	0	0

The new supply is obtained at a point approximately 2-1/8 miles west of the present intake, on Toomer's creek, which is a cutoff on the Northwest Branch of the Cape Fear river, approximately 7 miles long and is practically a long, sluggish canal. The Northwest Branch and the Northeast Branch join near the north end of Wilmington, and the new intake is connected to the pumping station by an intake line across the V-shaped strip of land between these two branches. Toomer's creek was recommended as a source of supply by Professor Earl B. Phelps in 1913 and later by George F. Catlett, formerly chemist and bacteriologist of the plant. Table No. 2 gives maximum, minimum and averages of Mr. Catlett's results, which indicate that this water can be purified by chemical filtration more economically than that of the east branch and that it is only slightly polluted.

24-INCH INTAKE DISCHARGE LINE.
Power transmission line follows pipe line. Intake station in background.

THE NEW INTAKE

The new intake is 11,389 feet distant from the original filtration plant (which is continued at the same site) and is connected with it by means of a line of 24-inch bell-and-spigot Class A cast-iron pipe, of which 636 feet across the Northeast Branch is of the flexible-joint type developed by the U. S. Castiron Pipe and Foundry Company, while the balance is supported on wooden bents above the surface of the ground, which is flat, swampy tidal land, boggy and wet and covered with water at high tide, but with firm, sandy soil 6 to 48 feet below the surface. The supporting bents are made of creosoted wood piles with 8-inch butts driven to a penetration that gives a maximum bearing of 10,000 pounds per pile. Each bent consists of two piles cut off at the proper level and capped with 8x8-inch creosoted wood, the bents being so located as to support each pipe one foot back of the bell. The line is level throughout.

The submarine line across the Northeast Branch was laid in accordance with the methods developed by the city of Norfolk, Virginia, on its Lake Prince development. A channel was first dredged for the full width of the crossing and of a depth sufficient to meet the requirements of the War Department for navigable streams, varying from 35 feet in the 100-foot

width of ship channel, to 2 feet at each bank, where connections were made to the bell-and-spigot pipe. The 35-foot depth gave a 5-foot cover over the pipe. The flexible-joint pipe was laid in this trench from a wooden cradle suspended between two barges and moved forward as each joint was made, the cradle being purchased from the city of Norfolk. When the cradle reached the further shore, the upper portion was cut off and removed, but the lower portion was permitted to remain as a support for the pipe, because the river bottom here is a series of rock ledges forming steps. Connections to the bell-and-spigot pipe were made with sleeves and the line was anchored to concrete deadmen by means of iron rods. A Venturi meter was placed in this pipe line so that an accurate record can be kept of the water pumped and as assistance in regulating the chemical dosage.

In order to deliver the water to the purification plant, a low-lift pumping plant was located at the new intake at Toomer's creek in a building 18x20 feet, comprising a brick superstructure on a reinforced concrete substructure supported by wooden piles which project 6 inches into the footing and floor slab. This was built in a cofferdam of Wakefield sheet piling carried several feet below low-water level. Difficulty was experienced in placing the concrete for the footing and floor slab, the hydrostatic pressure developed by the rise and fall of the tide breaking the concrete before it attained its final set. To

FLEXIBLE JOINT USED IN RIVER CROSSING.

solve this difficulty, the cofferdam was filled with fine beach sand and the substructure was built on this, above the influence of the tide, as a monolith, and was then settled into place on the piles as a caisson; the sand, thoroughly saturated with water, being removed from under it by an ordinary contractor's gasoline engine-driven double diaphragm pump. The footing and floor slab and walls of the substructure were designed to withstand a 14-foot head of water and resist flotation, and a 3 per cent. mixture of toxament was used as a waterproofing agent. The floor is of such depth that the pumps are submerged at all times.

The pumping equipment consists of two motor driven Morris centrifugal pumps with a capacity of 4,000,000 gallons per day against a 100-foot head, and a small float-operated sump pump. The raw-water pumps have a 24-inch suction and discharge. The motors are automatically controlled from the filtration plant and are G. E. 3-phase, 60-cycle, 2,200 volt, 100-horsepower, direct-connected to the pumps and mounted on the same base. The sump pump is vertical, motor-driven. Up to the present no occasion has developed for using it except to dispose of the waste water from the glands of the pumps, as the concrete walls are impermeable to water and the interior of the structure is bone dry under a 9-foot hydrostatic head.

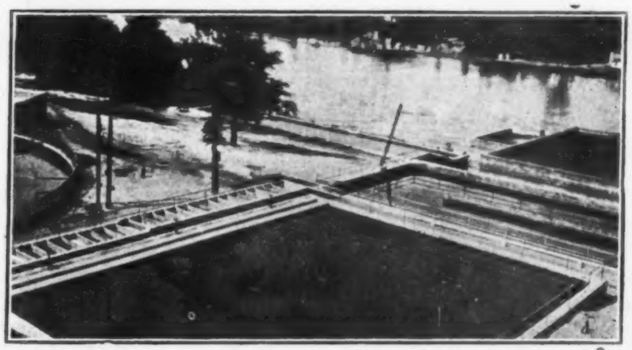
The station is completely wired for lights, with sockets for extension cords and lamps at convenient points. Current for lighting and pumping is furnished from the filtration and pumping station, the power being controlled from the switchboard at this station.

PURIFICATION PLANT

Water from the new intake on reaching the purification plant flows through a new, closely baffled mixing chamber and thence through a reconstructed coagulating basin to the filters. The plant being located on the hillside at the river-bank, the basins are set at different elevations, all higher than the filters, number one being on the hilltop, number two on the slope and number three approximately 5 feet above the filters.

Basins 1 and 2 had a longitudinal dividing wall with inlet and outlet at the same end, while in basin 3 the inlet and outlet are at opposite ends. Velocities through the different basins varied from 1.2 to 2.4 feet per minute, which was found to be too high for effective sedimentation. After studying the operation of these basins with a view to securing lower velocities it was decided to construct the mixing chamber along one side of basin number 1 and reconstruct this basin, and use number 2 and 3 for secondary treatment of the water, if necessary.

In the old plant all chemicals were added at the suction side of the raw-water pumps and no other mixing secured except in passing through the centrifugal pumps; but in the new supply a mixing chamber was thought desirable to insure a thorough mixing of the chemicals with the water. The mixing chamber is of the up-and-over type, 6 feet wide, 12 feet deep and



INLET END OF MIXING CHAMBER AND WEST HALF OF RECONSTRUCTED COAGULATING BASIN.
Basins Nos. 2 and 3, filter and storage reservoir in background.

148 feet long. Wooden baffles are spaced 14 inches center to center and the velocity is .8-foot per second when treating 6,000,000 gallons a day, and the detention period is 20 minutes. Chemicals are introduced directly over the raw water inlet. The outlet of the mixing chamber is into a covered channel separating the mixing chamber from the coagulating basin and extending the full length of the basin, gates and valves being provided which will permit directing the water into basin No. 1 or by-passing it to either or both of the other basins. The mixing chamber can be drained by means of drain lines and sumps, and flap gates in the baffles extending to the bottom of the chamber. No accumulation of silt or floc is anticipated with the velocity that is maintained in the mixing chamber.

In reconstructing basin No. 1 to serve as a coagulating basin, the dividing wall was removed and the direction of flow changed to pass across the width of the basin, which is 60 feet, instead of along the 148 feet of its length. This gives a surface velocity of 0.35-foot per minute instead of 1.7 feet per minute, without changing the detention period of approximately three hours when operating at 6,000,000 gallons per day. Water is admitted to the basin from the mixing chamber by means of six 12-inch sluice gates in the outlet channel equally spaced along the length of the basin. In order to distribute the entering water uniformly across the basin, a wooden wall was placed in front of the inlet for the full length of the basin, composed of 2x8 material with 1-inch spaces between the separate planks; while a similar wall is placed across the center of the basin to break up surface currents due to wind action. The water leaves the basin over a concrete skimming weir to four 12-inch outlet lines, which, in turn, discharge into a 16-inch cast-iron header which conveys the water to either of the other two basins or direct to the filter bed. Bell-mouth overflows connected to the sewer prevent the overflowing of the basin. In addition, there are drain pipes, by-passes, effluent lines, etc.

The old solution tanks and chemical feed apparatus were too low to supply chemicals to the new mixing chamber by gravity, and dry-feed machines were installed at a higher elevation, one for alum and two for lime, being of the type manufactured by the Roberts Filter Manufacturing Company. The machines are motor-driven and controlled by individual switches. A revolving screw conveyor works the chemical from the hopper to the front end of the machine, where it drops into a cast-iron up-and-over mixing box, where it is taken into solution by a stream of water flowing through the box continuously. The machines are provided with two speeds and with three adjustments of the conveyor speed for each speed, permitting a wide range of chemical dosage. The chemical solutions are carried to the mixing chamber and basins through 1-1/2-inch galvanized iron pipe, each turn or connection in this being made with a tee, one opening of which is plugged. High-pressure water connections are made to the solution lines, enabling the operator to flush the lines daily and prevent the deposition of chemicals in the line.

The filter plant now consists of twelve 500-gallon units. The under-drainage system of each unit formerly consisted of a 6-inch central cast-iron semi-elliptical manifold with laterals of 1-1/2-inch and 1-1/4-inch wrought-iron pipe and umbrella-type strainers. All but four of the filter units had been equipped with Earle controllers, and four with hydraulic valves and tables, and these were discarded and Simplex controllers provided throughout (the other four already having Simplex controllers) and all valves are now hand-operated from floor stands on the operating floor. As high-velocity wash was contemplated, all gravel, sand and under-drainage systems were removed, the old manifolds being too small for this type of wash. The old manifold was replaced with a semi-circular manifold of area equivalent to a 10-inch pipe, with laterals of 1-1/2-inch galvanized pipe on 6-inch centers, carrying strainers 6 inches apart, the strainers of the old system being cleaned and used again. The full pressure of the wash-water tank was then applied to the system and any strainers blown out were replaced and the test continued until all held. Gravel was then placed as follows: 5 inches of 2-1/2-inch to 1-inch gravel, 4 inches of 1-inch to 5/8-inch, 4 inches of 5/8-inch to 3/8-inch, 3 inches of 3/8-inch to 3/16-inch, and 2 inches of 3/16-inch to a number 10 mesh, followed by 30 inches of sand with an effective size of 0.43 mm. and a uniformity coefficient of 1.51. The wash water troughs were raised to give 24 inches from the sand to the top of the trough, the troughs from eight of the units being combined and used in four units to secure the capacity needed with the high velocity wash, and new troughs provided for the remaining four units.

Each unit is equipped with loss-of-head gages and sample pumps of the Humphrey type, set on cast-iron stands. A sampling cabinet is provided for drawing water from the raw-water main and the coagulating basin and composite filter water.

A 50,000-gallon steel wash-water tank on a 40-foot tower provides water for high-velocity wash, the tank being filled from the high-pressure main and kept at a constant level by means of a Golden Anderson altitude valve.

The work of overhauling the filters was so planned and conducted that shutdowns of only short duration were necessary for cutting in new valves and piping.

A 160,000-gallon filtered water well, constructed in 1906, is continued in use and water is pumped from it to the distribution system, chlorine gas being added at the pump suction. Duplicate chlorinating units are provided.

A fully equipped laboratory is maintained at the plant jointly by the County Board of Health and the Water Department, with a trained chemis and bacteriologist in charge. Complete analyses and daily records of operation are maintained.

HIGH PRESSURE PUMPING PLANT

The new high-pressure pumping plant is motor-driven, the old steam units being held in reserve. There is a standard General Electric five-panel switchboard, fully equipped; each of the service pumps, the booster pump, the Toomer's creek intake pumps and the incoming power each having a panel. The local power company furnishes 2-phase, 60-cycle, 2300-volt current at the plant, which is converted to 3-phase by Scott connected transformers.

The service pumps are motor-driven centrifugals with a capacity of 3,000,000 gallons per day against a 200-foot head. Each pump has an independent suction connected to a 30-inch header and can discharge independently into the high-pressure system or into the suction of the booster pump. These and the booster pump, complete with motors, were furnished by the Morris Machine Works.

The booster pump has a capacity of 6,000,000 gallons per day against a 300-foot head and is used only for giving pressure greater than ordinary. General Electric slip-ring motors are used, direct-connected to the pumps by flexible couplings. Drum controllers and resistors are used with the service and booster pump motors. Power from the switchboard to the Toomer's creek intake station is conveyed through a submarine cable under the river and thence over a three-wire overhead pole line, the submarine cable being a standard steel-clad lead-incased of three No. 1 conductors, insulated for a working pressure of 3,000 volts. The overhead ground wire is quarter-inch galvanized steel wire and the conductors are No. 1 B. & G. gage hard-drawn bare copper wire. The 30-foot juniper poles are bolted to creosoted stub piles by galvanized iron bolts and wrapped with wire. The intake pumps take the 2200-volt power direct from the line, but transformers step down the voltage to 220 for operating the sump pump and for lighting.

BENEFITS DERIVED

The improved plant furnishes a water supply that, although slightly polluted, can receive no pollution from the sewage of the city either now or in the future, or from sea-water. In addition, it operates more economically than the old plant. Flocculation tests made by George D. Norcom, director of the plant laboratory, showed that the new supply would require only half as much chemicals to secure results as the old supply, and this has been confirmed by service operation.

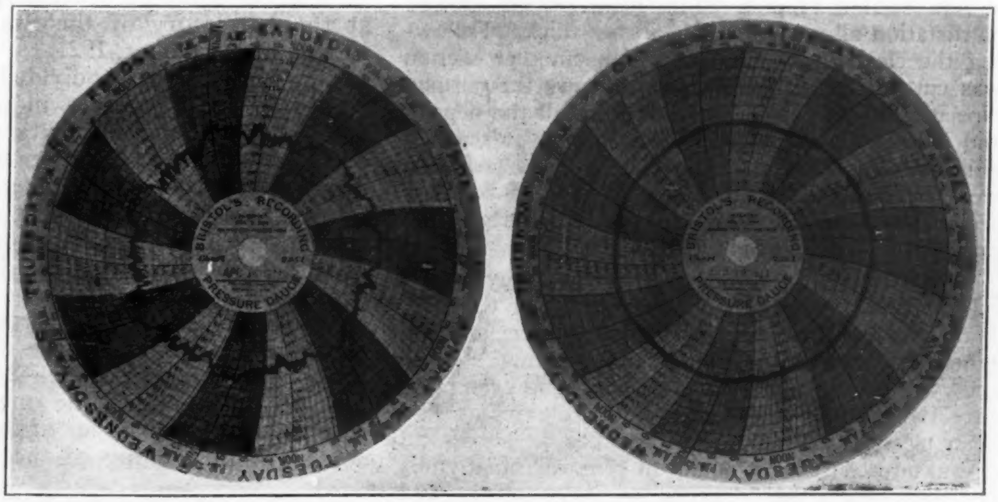
Other economies are secured by the discontinuance of sewage pumping and by the electrification of the high-pressure pumping equipment. It is estimated that the annual saving will be sufficient to offset the interest on the bond issue and also retire the serial bonds as they become due. The total cost of these improvements, including engineering, was approximately $260,000.

The engineers for this work were the Carolina Engineering Company of Wilmington, North Carolina, of which G. H. Bishop is chief engineer, and the writer sanitary engineer. Tucker & Laxton, Inc., of Charlotte, N. C., were the general contractors, E. L. Scruggs being their superintendent; The Diamond Steam Boat & Wrecking Company of Wilmington was the sub-contractor for the submarine pipe line. J. H. Cowan is mayor and commissioner of public safety; J. E. Thompson, commissioner of finance; R. C. Cantwell, commissioner of public works; McKean Maffitt, superintendent of water; George D. Norcom director of laboratory, and J. H. Sweeney, chief engineer of plant. The writer is indebted to Mr. Norcom and Mr. Sweeney for the operating and historical data incorporated in this paper.

Cleaning Water Mains in Manhattan

Results secured from cleaning water mains in Manhattan, Kansas, were described in the June issue of "Kansas Municipalities," by B. L. Ulrich, superintendent of water works. The salient points of his paper are given below.

The city obtains its water supply from the underground flow of the Blue River valley by means of a series of wells. This water contains a large amount of iron, averaging from 7 to 10 parts per million, and an average total hardness of 450 parts per million. Pumping and storage of the water resulted in aeration and a partial oxidation of the iron, with the result that a part was precipitated and settled throughout the distributing mains.



Previous to cleaning mains. After cleaning mains.
PRESSURE GAUGE RECORDS SHOWING DROP DURING PEAK LOADS.

A serious loss of pressure became noticeable about 1914, but not until 1922 could the voters be persuaded to authorize a bond issue to cover a filtration and iron removal plant and the cost of cleaning the mains. Following an educational campaign, in that year they voted a bond issue for this purpose, in which $14,000 was included for cleaning the mains. A preliminary investigation showed that about eight miles, comprising all of the original system laid in 1887 and some later extensions, required cleaning. In January, 1922, a contract was made with the National Water Main Cleaning Company to clean between five and ten miles of 4-in. to 12-in. pipe, the company to furnish superintendence and equipment and the city to furnish all labor and material required. Work was commenced in August and 7.8 miles of pipe was cleaned at a total cost of $4,807 or approximately 11.6 cents per foot. The force used, in addition to the cleaning company's superintendent, consisted of a foreman, one caulker, six men and a truck. The average amount of pipe cleaned per day was three blocks. The work was completed in three months.

The method of cleaning was that ordinarily employed by this company, consisting in opening the pipe at the two ends of a stretch to be cleaned, inserting a cleaning machine and drawing it through by cable.

During the progress of the work no consumers were deprived of water service for more than one day, as in every case the section shut off to be cleaned was completed and the water turned back on the same day. Following the cleaning, every service was tested for possible stoppage and in only a few cases was any trouble encountered in the clogging of curb cocks or service lines and such stoppages were easily removed by means of special force pumps.

Incident to the cleaning a number of interesting conditions were found that would otherwise never have been discovered. A 6-in. mass of lead was found in an 8-in. main, and at two other places pieces of 1 x 4-in. boards 12 feet long were found in mains that had been in service for 35 years.

In order to demonstrate the effectiveness of the pipe cleaning, Mr. Ulrich had, before cleaning, cut a 4-ft. section from a 10-in. main, which showed incrustation all around it 2½ inches thick. Following the cleaning of the same pipe, another section was cut out near the first one showing the cleaned pipe in almost perfect condition with all the deposit and incrustation removed without injury to the original coating on the pipe. These two specimens were exhibited in a store window in the business section and quite successfully combatted the usual criticism of uninformed citizens.

The effect of the cleaning is shown by charts taken from a recording gauge located at the City Hall, one for a week prior to the cleaning and the other for a week following the cleaning. These show a great improvement in constant and even pressure maintained at all times after the mains had been cleaned. As the city now has in successful operation a softening and iron removal plant, it is not anticipated that removal of incrustations and deposits will again be required.

Dover's Water Works Auto Truck

Last year the water department of Dover, N. H., purchased a 1½-ton Reo truck to take the place of the horse and wagon formerly used. The purchase was made on February 28, the cost was $1,623.75. During the remaining ten months the cost of upkeep was $39.94 for horn, curtains, repairs, etc., $144.68 for gasoline, $15 for oil and $10 for chauffeur, a total of $209.62, or at the rate of 68.5 cents per day. The total distance traveled was 4,725 miles, giving a cost of 4.4 cents per mile.

The superintendent of the department, Henry E. Perry, in his annual report, compares this with the cost of the horse and wagon during the same period of 1921, stating that the stable account had been $441.50; shoeing, repairs to wagon, etc., $96.65; veterinary service, $30.50; a total of $568.65, or a rate of $1.85 per day.

Size of Filter Sand*

Effect of size of sand on operation details and results, as indicated by comparison of filters at Lima, Ohio.

By E. E. Smith, 2nd†

The six units at the Lima filtration plant have separate outlets to the clearwell, so that it has been customary to collect separate samples at times of general sample collection for plant control, using the average bacterial count from separate plates as the estimate for filtered water prior to disinfection. During the year 1921, all bacterial counts were made with an incubation temperature of 37° C.; during the year 1922 a change was made to an incubation temperature of 20° C., all counts being made with "Standard Methods" agar. Exact measurement of initial and final loss of head have been made and other engineering data have been collected, the summaries of which are herewith presented. The mechanical analyses of sand samples were made at the laboratory of the State Department of Health in December, 1921.

The filters may be divided into two groups according to differences in physical characteristics of the filter sand. Filters 1, 3 and 5, located on the west side of the filter gallery have a sand of smaller size and greater uniformity than filters 2, 4 and 6, on the east side. Those filters having the finer and more uniform sand also have a slightly thinner sand layer, or at least a greater distance between the sand line and the tops of the wash-water troughs. During the two years' observations the rate of washing has been uniformly the same—24 to 25 in. rise of wash water—applied for one minute at a low rate, then the remainder of the recorded time of wash at full opening of the wash water valve.

*Paper before Ohio Conference on Water Purification.
†Superintendent of Filtration at Lima, Ohio.

Table I—Description of Filters

Filter number	1	3	5	2	4	6	1, 3, 5	2, 4, 6
Effective size (mm.)	0.37	0.37	0.38	0.44	0.42	0.42	0.37	0.43
Uniformity coefficient	1.22	1.27	1.21	1.36	1.38	1.43	1.23	1.39
Distance of top of sand to top of trough (in.)	29.62	29.88	29.75	28.38	27.00	29.00	29.75	28.15

Table II—Comparison of Performance of Filters as Measured by 37° C. Bacterial Count, Year 1921

Filter number	1	3	5	2	4	6	1, 3, 5	2, 4, 6
Filter efficiency (bacterial removal)	81%	81%	82%	77%	77%	80%	81%	78%
Average wash water used (gals.)	28,900	28,900	28,500	28,800	28,100	28,500	28,800	28,500
Time of wash (minutes)	4:40	4:34	4:51	4:12	4:15	4:11	4:42	4:13
Length of run (hours)	25:00	22:44	25:50	30:46	30:10	30:21	24:31	30:26
Initial L-of-H (ft.)	1.45	1.27	1.38	1.23	1.12	1.35	1.37	1.23
Final L-of-H (ft.)	11.00	11.10	11.[illegible]0	10.90	10.90	11.10	11.03	10.97

Table III—Comparison of Performance of Filters as Measured by 20° C. Bacterial Count (January-October, 1922)

Filter number	1	3	5	2	4	6	1, 3, 5	2, 4, 6
Filter efficiency (bacterial removal)	64%	59%	72%	69%	68%	71%	65%	69%
Average wash water used (gals)	26,100	25,300	26,100	25,400	24,800	25,500	25,800	25,200
Time of wash (minutes)	4:26	4:05	4:18	3:41	3:40	3:48	4:12	3:43
Length of run (hours)	16:00	14:29	15:07	18:32	19:24	18:01	15:13	18:39
Initial L-of-H (ft.)	1.44	1.35	1.59	1.32	1.21	1.52	1.46	1.35
Final L-of-H (ft.)	8.46	8.53	8.45	8.36	8.50	8.47	8.48	8.44

The time of wash has been fixed to maintain as nearly as possible the same volume of wash water passing through the filter at each wash.

A study of the figures recorded shows that the filters with the finer sand require approximately one-half minute longer to pass the same quantity of wash water; they have consistently higher initial loss-of-head; and always shorter runs, requiring higher percentages of total wash water. The figures for bacterial removals do not indicate any such consistent differences, but show practically the same removals. For the two periods the removal of B. Coli has been practically the same—93 per cent.

All of the filters show sand of size and uniformity falling within the limits suggested by Mr. Dittoe in November, 1921—less than 0.45 mm. During 1922, the filters were allowed to reach a final loss-of-head of approximately 8.5 ft., while in 1921 they were permitted to reach the practical limits of loss-of-head—11 feet; and the total percentages of wash-water for the two periods—4.1 for 1922 and 2.8 for 1921—result from such change in operation. Other conditions have also caused the increase in percentage; namely, poor coagulation in cold weather, filter growths in warm weather, as well as the attempt to consistently produce a filter effluent below a confirmed B. Coli index of 2 per 100 cc.

Filter runs for those filters with the coarser sand were approximately 24 per cent. longer than those with the finer sand. Had all filters been equipped with filter sand of 0.43 mm. effective size, it is probable that the average percentage of washwater would have been reduced possibly half of this difference, or instead of 2.8 for 1921 it might have been 2.5 per cent., and instead of 4.1 for 1922 it might have been 3.6 per cent. Although these conclusions are based upon small differences in size of filter sand, they are also based upon many observations. They serve to indicate that small differences in size of sand are important, and that careful attention to size and grading of filter sand may have far-reaching results in operation.

Water Services in St. Paul

During 1922 St. Paul installed 2,500 new service connections, varying in size from ⅝ inch to 6-inch. A meter is placed on every connection except those for automatic fire sprinkler installations or fire pumps, "where it is evident that the water will not and cannot readily be used for any other purpose than for fire," says the annual report, probably in a spirit of charitable optimism.

During the year, a ruling was made by the Board of Water Commissioners that on and after January 1, 1923, the minimum size connection to be installed would be a ¾". It was also decided that service connections of ¾" to 1½" inclusive, would be of lead, and that service connections of 2" and over would be of cast iron. Galvanized iron, which was formerly used, did not prove satisfactory in all cases. In some portions of the city the galvanized iron deteriorated very rapidly and gave a great deal of trouble after a very few years of service.

Waterworks Services

The Committee on Standardization of Services of the American Waterworks Association at the annual Convention this year reported on the mechanical and chemical problems of waterworks services in the progress report which it submitted.

Concerning mechanical considerations, it stated that, considering not only the first and replacement costs of services but also taking into account the interruption of service and inconvenience of street openings, it is no exaggeration to say that a service that will last twenty-years is worth five times one that will last only ten years. In fact, a service should be expected and planned to last as long as the water main to which it is connected.

"Many materials are used for services and many have been of the temporary class requiring frequent renewals. Galvanized iron has been, probably, the most popular in past years and many services installed forty and fifty years ago

of old style wrought iron galvanized are in service today. Steel pipe has not had as long a test to show its lasting qualities, but it is doubtful if either can be compared favorably with cast iron as a long-lived material.

"The life of lead is well known, but the effect on health of its use is not so well understood. While there are few cases of lead poisoning from the use of lead water pipes on record, the information on the subject is meagre.

"Brass pipe has been used lately, but not long enough to fully test its lasting qualities. It has ample strength and is free from welding seams, one of the defects in wrought iron and steel pipes of small diameter. There is little or no record of its effect on health, but there is some prejudice against its use. In cost, heavy brass pipe compares favorably with AA lead and costs less than AAA lead. Pure copper pipe can be had at about the cost of AAA lead. These estimates are based on the present market quotations for these materials, these being 10c per pound for lead pipe, 26c for brass and 28½c for copper. At these prices ¾-inch pipe would cost 35c per foot for AA lead, 47½c for AAA lead, 32c for regular brass, 42c for extra heavy brass, 37c for regular copper and 49c for extra heavy copper.

"With brass pipe the cost of joints would be eliminated unless the usual short connection used with iron and other rigid service pipes is still considered necessary. Whether the necessary flexibility to obviate settlement breaks can be secured without the use of the lead connection has not, so far as your committee has been able to learn, been worked out or tested."

From the chemical point of view the committee has been studying, through three chemists, the action of different characteristics of water upon lead and believes that a thorough investigation of the effect of the use of lead pipe on health should be made before it is recommended by the Society.

Charlestown Water Treatment Notes

In his annual report for 1922, J. E. Gibson, manager and engineer of the Water Department of Charleston, S. C., describes the use made by the department of the hydrogen-ion control method in connection with softening the water supply of the city, and also the use of caustic soda instead of hydrated lime. This section of his report is as follows:

"We have, for a number of years, been using hydrate of lime to restore the alkalinity of the water after filtration. In this process the water is hardened slightly. The raw water has an average hardness of about twelve parts per million, and when treated with alum and afterwards with hydrate of lime the hardness is increased to an average of twenty to twenty-three parts per million. This is considered a soft water by water works men; it is, however, considered hard by our people who are accustomed to the use of cistern water.

"In recent years, the hydrogen-ion or pH control method has been developed and used in determining the acidity or alkalinity of public water supplies. A neutral water is spoken of as having 'a hydrogen-ion or pH value of 7.'

"After conducting a series of experiments, we found that tests made in accordance with recognized methods to determine alkalinity, showed that the Goose creek water contained fourteen to twenty parts per million alkalinity; by the hydrogen-ion or pH method, it was slightly acid. Hydrated lime being a weak alkali, we decided to conduct some experiments using a strong alkali, such as caustic soda to restore the alkalinity after filtration in an effort to increase the hydrogen-ion or pH value to or above the neutral point. We adopted caustic soda as being the more desirable alkali as it effects a greater reduction in the carbonic acid contents and also artificially softens the water.

"We began the treatment of the water with caustic soda on September 7th, and have continued it up to the present time. We find that it requires about two-thirds of a grain of 76% caustic soda per gallon to maintain the alkalinity at about eighteen parts per million and reduce the carbonic acid contents within two or three parts per million, as against approximately one and one-fourth grains of hydrated lime. The alkalinity in the filtered water has been maintained at the same point as measured by the erythrosine methods, and the hydrogen-ion or pH value has been increased from about six and six-tenths to seven and one-tenth, or an undoubtedly alkaline condition. The water has been artificially softened from an average of twenty-one parts per million hardness to twelve parts per million, or approximately the same as that of the raw water.

"There has been a very great aesthetic improvement noted, in that as the calcium carbonate contents reacted with soap forming calcium oleates that are only partially soluble in water. These oleates curdle and settle at the water line of wash basins and bath tubs causing complaint. With sodium hydrate the reaction forms sodium oleates which are soluble, and therefore, this curdling has disappeared.

"The increased cost of the sodium hydrate treatment per day over that of lime, based upon a treatment of six million gallons of water per day, is approximately $16.00. Taking the generally accepted statement that it requires two ounces of soap to soften one hundred gallons of water for each grain of hardness per gallon, expressed as calcium carbonate, and that one-tenth of the total water supply is softened for laundry, domestic and manufacturing purposes, and that on an average we soften the equivalent of one-half grain of calcium carbonate, the total soap and boiler compounds saved per day would be six thousand ounces or three hundred and seventy-five pounds. Further, if the average cost of soap is eight cents per pound, we have a gross saving to the consumer of $30.00 per day, as against an increased cost to the Department of $16.00 per day. There is undoubtedly a fur-

ther indeterminate saving in that with the higher hydrogen-ion or pH value obtained with sodium hydrate, there is a reduction in the corrosive action of the water on the mains, and there is the aesthetic value, in that the curdling with soap is almost entirely eliminated."

Benton Harbor Purification Plant

Recently completed plant that contains some unusual features and treats both river and well water, which carry different percentages of iron. Work done by city-paid labor, under a contractor as superintendent.

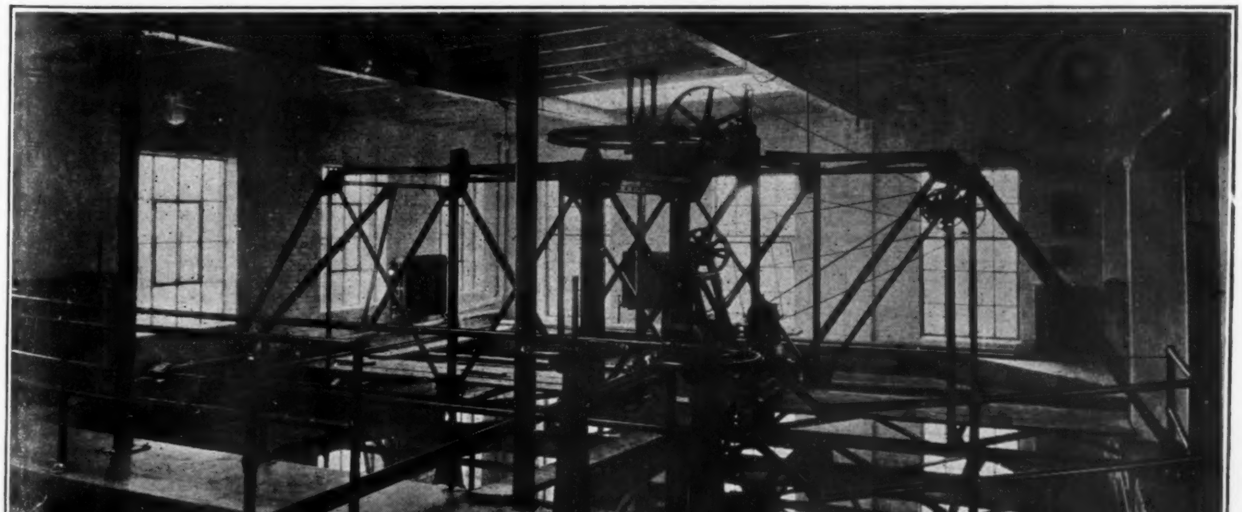
The city of Benton Harbor has recently completed a water purification plant which contains several features of unusual interest, one of which is the overdosing with chemicals of a part of the water only and later a combination of this with the entire supply; another is the use of a Dorr thickener, it being believed that this is the first instance of such use in a water works plant.

The plant was designed at first for treating St. Joseph river water, which was intended to supplant that previously obtained from twenty-seven 6-inch wells, the supply from which had become inadequate. However, at the suggestion of the engineers the city commission decided to use the well water up to its capacity and supplement it with river water in times of high consumption, the principal object being to maintain a supply of cool well water as long as possible.

The waters are essentially different, the well water being bacteriologically pure, but containing an excessive amount (two parts per million) of soluble iron salts and considerable hardness, but the river water, while nearly as hard as the well water, contains no iron and does contain harmful bacteria. The problem was therefore one of building a plant adaptable to treating two types of water, removing the objectionable iron and also hardness in the well supply and bacteria and hardness in the river water.

The physical features of the new plant consist of a concrete intake crib in St. Joseph river connected by 1,200 feet of 14-inch cast iron pipe to a concrete well 12 feet in diameter and 17 feet deep; a remodelled pump room containing two 2-million-gallon simplex, double acting, compound piston pumps made by the Union Steam Pump Co., for low-lift service, and one Worthington 2-million-gallon duplex, double acting, compound, piston pump, and two old 1½-million-gallon Hughes duplex pumps that had been in constant service for 31 years and were completely overhauled; three old 75 h. p. fire-tube boilers, which received no repairs; and the water purification plant.

The water purification plant comprises five concrete mixing chambers with propeller agitators, two of them about 8 feet square and three about 14 feet square, and all 18 feet deep; three dry feed chemical machines, two for hydrated line and one for alum; a Dorr thickener with concrete tank 29 feet in diameter and 14 feet deep; two coagulating basins, each 29 by 87 feet by 18 feet deep, with a capacity of 325,000 gallons; four filter beds, each with a rated



DORR CLARIFIER—FIRST INSTALLATION IN A WATER FILTER PLANT.

capacity of 500,000 gallons per day; one clear water reservoir 87 feet by 108 feet by 12 feet deep, with a capacity of 750,000 gallons, and one 40,000 gallon elevated steel tank, 59 feet high, for storing wash water. A two-story brick filter house covers the pipe gallery and filter operating floor and contains storage space on the top floor for 100 tons of lime and 50 tons of alum. On this floor also are the engineer's office, testing laboratory and toilet. A hydraulic elevator facilitates handling material. Smaller apparatus includes chlorinating equipment, marble filter operating tables, a 14″ x 7″ venturi meter and an 18″ x 9″ venturi meter, rate controllers and loss-of-head indicators on each filter, a depth gauge for the clear water basin, and necessary pipe, fittings, valves, etc.

In designing the plant great flexibility was aimed at so that well water and river water can be treated separately or mixed as desired.

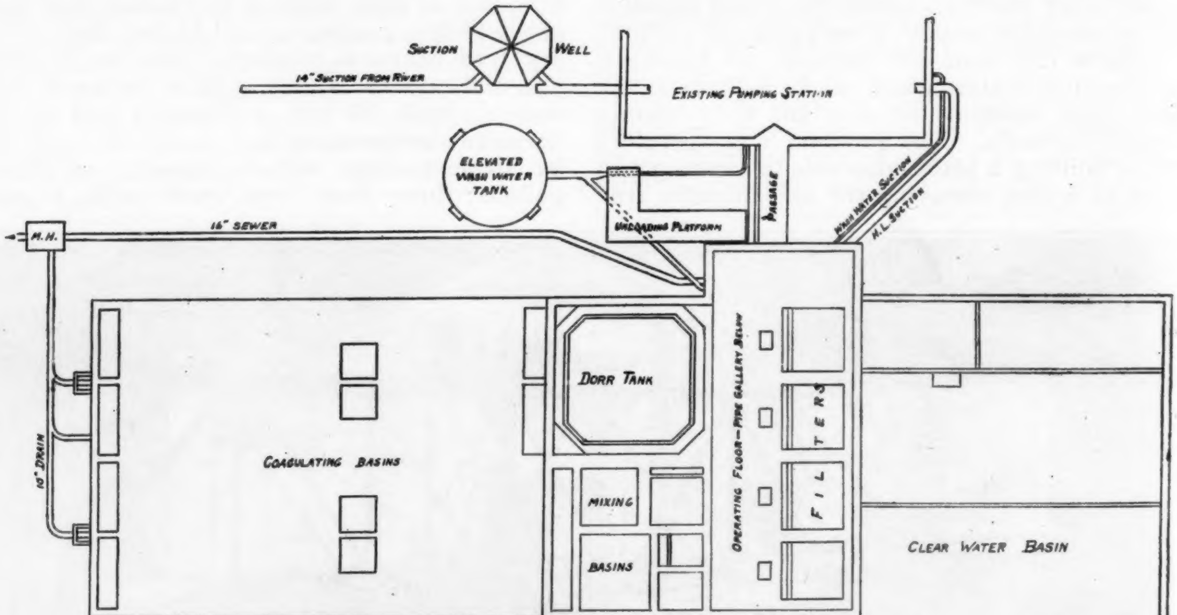
The plant has a rated capacity of two million gallons per day. Water is raised by the low-lift pumps into five mixing basins. The two 8-foot basins receive 25% (or any other desired proportion) of the total raw water flow and to this is applied the full dose of lime and it may receive return sludge from the clarifier, and alum or sulphate of lime if desired. The three larger basins receive the remainder of the raw water. The charge of the chemicals into the 25% of the water produces a quick reaction and large floc. After a retention period of about 45 minutes this overdosed portion is mixed with the remaining 75% in the other three basins, which are mechanically agitated by motor driven propellers, one in the bottom of each tank, and operated in series.

From the mixing basins the water travels to the Dorr clarifier, where about 90% of the solids is removed by continuous operation. Some of the sludge from this tank can be returned to the first mixing basin and there recirculated and assist in the agglomeration of the floc, or all can be discharged into the sewer. Provision is made for applying alum at the outlet of the Dorr clarifier. (Since writing the above we have been informed by Pearse, Greeley and Hansen, the engineers, that practical operation of the plant has shown that there is no advantage in over-treating one-quarter of the flow for softening purposes, because of the fact that the water contains considerable magnesium and it has proved undesirable to add enough lime to any portion of the water to precipitate the magnesium hardness. In other words, a somewhat better efficiency is obtained by adding the lime to the whole body of the water. The return of sludge from the Dorr thickener, however, is proving very useful in agglomerating the precipitate.)

The Dorr effluent goes through two sedimentation basins in series. From the second of these the water travels onto mechanical filters of the usual type and thence into the storage reservoir.

When operating at the rate of two million gallons per day, the detention periods are three-quarter hours in the mixing basins, about one hour in the Dorr clarifier and eight hours in the two sedimentation basins.

The intention is to remove practically all of the iron and part of the temporary hardness as well as a large percentage of the bacteria. No effort is made to remove any of the permanent



LAYOUT OF BENTON HARBOR FILTER PLANT.

VIEW OF PLANT, LOOKING NORTHWEST.

hardness nor all of the temporary hardness, but the reduction will be approximately from 225 parts per million to 100 or 125 parts, which will bring it about the same as Lake Michigan water. The calcium or magnesium bicarbonates and the iron bicarbonates combine chemically with hydrated lime and settle out in the clarifier and sedimentation basins. Aluminum sulphate is used as a coagulant.

Attention is called by the engineers to the possibility that if raw water be turned onto the sand filter it may deposit iron on the sand grains and this therefore is warned against. It is also suggested that, should mono-carbonates deposit on the sand grains of the filter (which, however, is not expected to occur), it may be desirable to inject carbon dioxide gas into the water before it goes onto the filters, which will render the carbonates soluble and prevent their being deposited in the filter. It is also suggested that it may be desirable to aerate the water to remove odors, tastes or color and that this can be done at a moderate cost by building an aerator on top of the coagulating basin and connecting the raw water line in the pipe gallery to this.

PIPE GALLERY.

The piping and valves are so arranged that the mixing basins, the Dorr tank and the coagulating basins can be by-passed separately or together if desired. The filters, however, cannot be by-passed nor can the entire filter plant.

The chemicals are supplied by dry feed machines and the feed pipes are so arranged that lime and alum can be applied at several different points, which may be desirable at different periods with different rates of operation and treating different waters.

In their report to the city, the engineers stated: "Each filter operator should endeavor to learn as much as he can about filtration and about this plant in particular, so that full advantage can be taken of all the mechanical features provided, such as by-passes, chemical feeding and operation on the sand filters. This plant presents many interesting problems to an experienced water chemist and engineer and if intelligently operated can help answer several questions which have been in water works men's minds for some time. In this way the city will be advertising itself and assisting the profession in general."

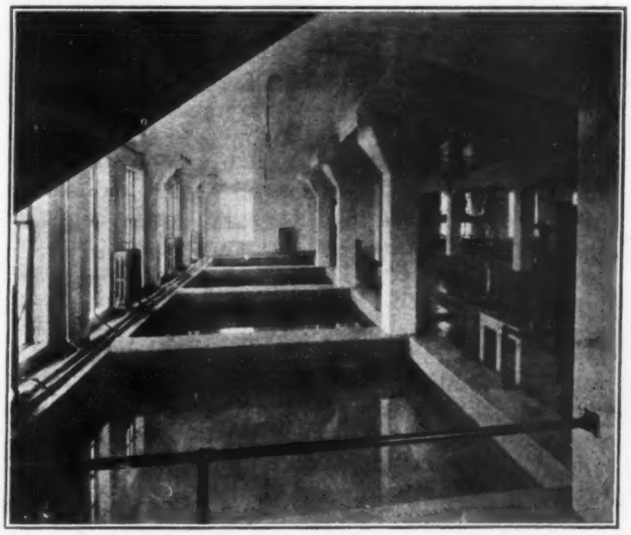
Dr. A. M. Buswell, chief of the State Water Survey of Illinois, assisted in starting the chemical control of the plant, and furnished for operator a chemist who had studied under him at the University of Illinois, which will apparently assure unusually good chemical control of this plant.

The plant is now using about 9 grains of hydrated lime and ½ grain of alum per gallon. No soda ash is used. This gives a reduction of about 50% in hardness and removes all of the iron. A reduction of 90% of suspended solids obtained by the Dorr thickener was shown possible by preliminary tests and for this reason it was decided that it would not be necessary to use as large settling basins as had formerly been the practice.

CONSTRUCTION

In January, 1922, there were many idle men in the city and largely for this reason it was decided to begin construction at once, and the work was inaugurated on January 18. Authorization had not been obtained to proceed with the entire plant and plans had been prepared for a clear water basin only.

The basin was built inside a cofferdam, consisting of triple 2-inch by 12-inch planks 18 feet long, supported by round piles. As the soil was almost pure sand and ground water stood within



FOUR FILTER BEDS, OPERATING FLOOR AND, AT RIGHT REAR, THREE CHEMICAL DRY-FEED MACHINES.

two or three feet of the surface, excavation was very difficult and costly. It was started by hand, but a crane was put in later. To prevent the completed basin from floating, due to high ground water, it was designed to carry four feet of earth on top of it. This structure was completed June 10.

From then on it was a race between plans and construction work. Authorization to proceed with the plans for a complete plant was received only two weeks before actual work started on the new portion. This was an unsatisfactory method of procedure and presented some difficulties, but was the only one possible under the circumstances. The coagulating tanks, mixing basins and Dorr tank were finished about August 20 and the filter boxes on September 20.

All of the excavation, concrete work, intake, building, exterior piping and miscellaneous work was done under J. M. Allmendinger, a local contractor, as superintendent, under an agreement with the city by which the latter furnished all material and paid all labor bills, while the contractor served as superintendent and furnished the use of his equipment to the city for a fixed fee. The engineers report that Mr. Allmendinger on the whole did his work well and tried conscientiously to save the city as much money as possible.

On August 10 separate bids were received for constructing a two-story building and its furnishings, and for installing filter equipment. Only one bid of $27,000 was received for the building and this was rejected and the work done by Mr. Allmendinger under the arrangement above described. Several bids were received for the filter equipment, the lowest being by the Norwood Engineering Company at $21,325 and the next the Roberts Filter Company, $300 higher. The contract was awarded to the former, which began work on October 19 and completed it on April 1, 1923.

Work on the river intake was held up all summer because of the delay in receiving a permit from the government. This was finally received on September 12 and work started on October 10. A cofferdam of 2-inch by 12-inch by 22-foot triple sheeting was put in the river during construction of the concrete crib. There are two lines of 14-inch cast-iron pipe between the crib and the valve box on shore, a distance of 275 feet. These pipe lines are installed in the river bed on timber saddles carried by pairs of round piles spaced 12 feet apart. These iron pipes were leaded together in lengths of 137 feet above water, suspended from the pairs of piles and lowered onto the saddles by ropes, and the joint between two such lengths was made under water by divers using lead wool. This work was made difficult by quicksand on the river bottom and it was impossible to complete it before cold weather set in, and it was carried on intermittently during the winter, but at greatly increased cost and difficulty because of cold weather. One line was completed November 15 and both lines were finally connected up on April 16, 1923. Water was put into the plant from the wells on March 25 and filtered well water was pumped to the city on March 30, while river water was first pumped on April 28.

Meantime the old pump room had been remodelled and cleaned up, two new low-lift reciprocating steam pumps installed, the old high-lift pump completely overhauled, rebored and renewed, and a new Worthington duplex pump put in. While the pumping plant has been greatly improved, it is realized that is not on so efficient an operating basis as could be obtained with a new plant and the engineers recommend that the installation of new water-tube boilers and high-duty pumping engines be kept in mind, to be adopted as soon as the money is available.

COST OF PLANT

Up to April 21, 1923, which saw the practical completion of the plant, the city had paid out for labor $63,603 and for material $82,750, while the contractor's fee was $10,000. The two new low-lift pumps cost $3,556 and the high-lift pump cost $4,000, while the Norwood Engineering Company received $21,325 for its filter plant. Adding $14,200 for engineering, etc., gives a total of $199,434.

Analysis of the costs shows that the average cost per ton for placing steel was $24.17 and for placing cast-iron pipe $27.60. In constructing the filtered water basin, the labor cost on concrete work per cubic yard was $3.03 on the floor, $3.54 for forms and $3.61 for concrete in the walls, and $4.40 for forms and $3.67 for concrete in the roof. In the sedimentation basins, Dorr tank and mixing basins, the cost (per cubic yard of concrete) for forms was 59 cents for the floor, $8.24 for the walls and $10.09 for the roof, while the concrete cost $3.29, $3.24 and $7.04 for these three parts of the construction respectively. Forms for the filter box cost $5.69 per cubic yard and the concrete $2.51. For the building, the forms cost $15.60 and the concrete $10.96 per cubic yard, and laying brick cost $33.98 per thousand. The above are all labor costs only.

The filtered water basin contained a total of 962 cubic yards of concrete, of which 326 was in the floor, 241 in the walls, 280 in the roof, 55 in the parapet wall and 60 in the columns and base. The coagulating, Dorr and mixing tanks contained 978 cubic yards of concrete, 280 in the floors, 546 in the walls and 152 in the roofs. There were 168 yards of concrete in the filter box and 176 in the building. The total amount of concrete in the plant was 2,284 cubic yards.

In addition to the concrete, there were used in the job 232,000 pounds of reinforcing steel, 317,800 pounds of cast-iron pipe installed by the city and 45,000 pounds by the Norwood Engineering Company. There were also 92,000 brick.

The engineers were Pearse, Greeley and Hansen, of Chicago. The resident engineer was H. D. White, to whom we are indebted for the above information. The city manager is Guy Tyler.

New Sewage Disposal Installations

Among questions submitted by us to city engineers in our latest sewerage questionnaire was: "Do you expect to build a new sewage disposal

plant?" The majority of the cities, of course, replied in the negative, but 71 replied that the construction of new sewage disposal works was either under way or contemplated.

Of this number two stated that a treatment plant had been completed this year, and 12 that such plants were under construction. Four replied that plans had been prepared or were being prepared. Eighteen stated that they expected to build such plants, 20 that they expected to build them, but would not do so this year; while 15 stated that such plants would probably be built, or, in some other terms, indicated that no final decision had yet been reached.

Garbage Disposal in St. Louis

Garbage disposal during past eighty-four years. Description of incinerator built last year.

After several years of discussion, experiments and public criticism, the city of St. Louis last year finally decided upon a method of disposing of its garbage, which is believed by the mayor, the board of aldermen and the director of streets and sewers to be the best available.

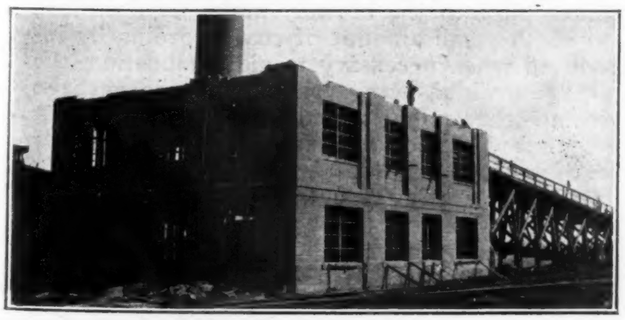
The plan decided upon is to locate four or five incinerators, one for each district of the city, with a view to minimizing the length of haul. One of these has just been completed, located on the bank of the Mississippi river a few blocks from the heart of the business district. The contract for this plant was let on May 19, 1922, for $69,812 to the Chicago Incinerator Company of Chicago.

HISTORY OF GARBAGE DISPOSAL IN ST. LOUIS

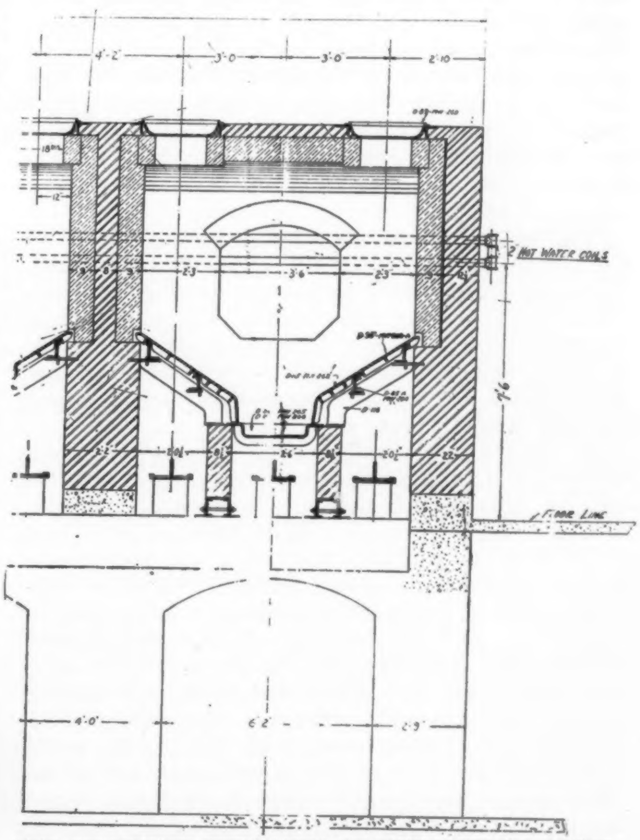
The Municipal Library of St. Louis informs us that the first ordinance relative to garbage was passed in December, 1839, requiring the city marshal to let at auction the removal of kitchen slops and dead animals. Amendments to this and new ordinances appear on the records at frequent intervals, numbering 47 in all. Contracts were let to different parties for the removal and disposal of the garbage, generally by dumping into the river until this was prohibited by the Federal authorities. In 1901 the St. Louis Sanitary Company contracted to dispose of the garbage by means of the Merz process, which party retained the contract for a number of years. In 1908 a contract was entered into with the Standard Reduction and Chemical Company for disposal of garbage in a plant on the Mississippi river outside of the city limits. This was for 10 years, but was abandoned by the contractor in 1913, when the city contracted with the Indiana Reduction Company to dispose of garbage delivered to it at receiving stations for 87 cents a ton, the previous contract having been for 27 cents a ton. In 1917 a contract was made for a Hirsch garbage reduction plant with a guarantee that the by-products would net about $3.60 per ton above operating expenses, the city advancing $17,000 for a test of the plant. This plant was partially constructed, but never used and the city recovered $15,000 on the contractor's bond. Other contracts were made in 1918, 1919 and 1920 with different parties, the 1920 contract involving removal of garbage to a point 62 miles south of St. Louis, the city paying 50 cents per ton and the freight.

In 1922 a contract was let for removing garbage to be delivered by the city to barges in the river, the contractor being paid $1.60 per ton. This contract was subject to cancellation at 90 days' notice. It is understood that some of this garbage is sold to farmers at the rate of 60 cents per ton, for feeding hogs. On February 15, 1923, a one-year contract was made with practically the same terms but paying $2.10 per ton.

The garbage collected during 1922-1923 totaled



ST. LOUIS INCINERATOR UNDER CONSTRUCTION.



ONE OF THREE FURNACES OF THE NEW ST. LOUIS INCINERATOR.

68,354 tons and cost $3.55 per ton for collection and $1.60 per ton for disposal, or a total of $5.15. Also, 11,857 dead animals of all kinds were disposed of. At present about 80 tons per day is being hauled to the incinerator plant and the balance is being delivered to the previous contractors on barges adjacent to the incinerator plant, by which it is carried down the river as above described. During the summer there are about 130 wagons in service hauling garbage. The wagons used weigh about 2,500 pounds and hold about 1 1/4 tons of garbage. Experiments are now being made with truck and trailer for hauling and this has reduced the cost of collection, but has not eliminated the mule-driven wagons.

It has been recommended that there be ultimately five incinerators, three of 100 tons capacity on the river and two of 150 tons capacity in the western part of the city, which will greatly reduce the cost of collection. During the summer the incinerators will probably be operated 24 hours a day, but only 8 hours per day in winter.

It is proposed to require that all garbage be drained and wrapped in paper, thus increasing the efficiency of the incinerator plants and obviating the hauling of sloppy garbage through the streets. It is also believed that all the hotels and large apartments should be required to put in their own incinerator plants.

THE NEW INCINERATOR

The incinerator built last year by the Chicago Incinerator Company is housed in a brick structure of fine appearance, two stories in height, with a chimney 125 feet high and entered by a ramp or runway which leads to the second floor. This plant was completed in October and burning of garbage begun on October 29th, and it has been in operation ever since. The original guaranteed capacity of this incinerator was 80 tons per 24 hours, but following a few weeks of operation some changes were made by which the capacity was increased to 104 tons.

The building is 57x38 outside dimensions and the ramp is a timber trestle about 300 feet long. There is a foundation consisting of 49 20-foot reinforced pre-cast concrete piles. The roof is supported by steel trusses. The radial brick chimney is 5 feet inside diameter and is lined with 9 inches of fire brick for the first 50 feet and 4 1/2 inches for the next 55 feet.

There are three furnaces, each containing two dump holes, and horses or other large animals can be introduced through a separate intake without dismembering. Each furnace is 5 feet by 8 feet, and about 8 feet from the top of the arch to the bottom of the grate, or rather a substitute for a grate. The omission of grates is the most striking feature of this incinerator. The bottom of the furnace is composed of a cast iron pan 3 1/2 feet by 5 feet, from which rise sloping sides also of cast iron, the whole being supported by brick piers, the brick side walls and four beams. In these bottom plates are about 300 holes or tuyeres, through which air is forced for supporting combustion. Those in the inclined plates admit the air at a lower pressure than those in the center. This arrangement is said to permit complete combustion with the least amount of excess air. The forced draft is furnished by two centrifugal blowers, each operated by a directly connected electric motor, which take the air from the storage hopper, or else from the ash tunnel and passing through the clinker pits, to be described later. The three furnaces are connected to a common combustion chamber, from which a brick flue carries the flue gases to the chimney, the draft being regulated by a damper operated by a hand-driven worm gear.

On the second floor is a storage hopper which is built of reinforced concrete and provided with drainage. As stated, the air for forced draft is drawn from this hopper, which prevents odors from escaping from it into the outer air. The storage hopper is triangular in vertical cross section, 9 feet 6 inches deep, and has a capacity of 60 tons of garbage. Wagons discharge into it through three holes each 3 feet by 3 feet and three others each 18 inches by 4 feet. Coal is dumped from the tipping floor through two coal holes each 18x24 inches which discharge it on to the operating floor in front of the furnaces. There are six openings in the hopper, one immediately opposite each of the charging holes. The holes in the hopper are, when not in use, closed with steel doors operated by pulleys and weights, and the openings into the furnace are closed by cone shaped covers raised by pulleys. Beyond these openings is another steel partition, forming a so-called air-lock. A large door in this partition in front of each charging hole permits the operator to rake the garbage into it.

Under the furnace is an ash tunnel 5 feet wide and 9 feet high through which runs a track of 2-feet gage on which run the vehicles which remove the ashes. Immediately in front of each furnace, beneath the floor level, is a clinker pit into which the clinkers can be drawn from the furnace through a clinkering door and so into the pit, a gate over the pit at the floor level having been removed for this purpose. A passage through the furnace foundation wall connects the clinker pit with the ash tunnel, and the clinkers when cooled can be discharged from the clinker pit into the cars operated in the ash tunnel. The tracks in the ash tunnel lead out of the end of the building and to the river bank.

A perforated cast iron door closes the opening connecting clinker pit and ash tunnel, to permit the air from the ash tunnel to pass through the clinker pit into the blower intake, as described above. A small amount of coal is ordinarily introduced when necessary to aid combustion, the garbage drained being practically pure garbage with no other refuse mixed with it. The amount of coal used is said to be less than 100 pounds per ton of garbage burned.

On the operating floor there is an office 8x12 feet and a wash and toilet room 6 feet by 12 feet containing shower baths. The forced draft fans are operated by motors, one of 10 h.p. and the other of 20 h.p. The air for the forced draft is introduced to the fans through a 20-inch vitrified

pipe leading into a 3-foot by 6-foot dust settling chamber, and by the fans is discharged into galvanized ducts, one 18x24 inches and the other 18x36 inches, under the furnaces. Under each furnace there are three 12-inch holes in the ducts, two of which supply air to the side grates and one to the fire box, the supply of air being regulated by dampers over each hole.

The temperature of the combustion chamber is maintained at 1200 degrees and here all gases are supposed to be consumed. Dead animals are incinerated in the combustion chamber.

Two 2-inch pipes pass through all three furnaces near the top and are connected to a 280-gallon tank, which is thus kept full of hot water, which is used for washing the tipping floor, for cleaning purposes, and for heating by means of radiators in the office and toilet room.

In operating the plant the garbage is hauled up the ramp, weighed on scales at the entrance of the tipping floor and then is dumped into the storage bin, from which it is drawn as needed and charged into the furnaces. One of the charging openings is above each side of each furnace, and these are used alternately so that the garbage on one side may be burning while the fresh garbage is being dried on the other. After having been dried on the side plates, it is raked into the pan or fire box, where incineration is completed. The ashes and clinkers are then drawn into the clinker pit, where they cool off.

The contractors guaranteed that this furnace would incinerate 80 tons of garbage in 24 hours without any nuisance or malodors; that it would use per ton of garbage not over 8 k.w.h. of electricity for the forced draft fans nor more than 120 pounds of coal. C. S. Butts, engineer of the Department of Public Utilities of St. Louis, reports that "Tests show that this capacity has been raised to 100 tons in 24 hours and that it requires less than one k.w.h. for each ton of garbage and less than 100 pounds of coal per ton of garbage. The plant is being operated 24 hours per day in three 8-hour shifts, and requires three men on the firing floor, three on the charging floor and one foreman for each 8-hour shift, and is incinerating garbage without any offensive odors or smoke for $1.00 per ton, showing a saving of $1.10 per ton over the present contract for dumping it on barges at $2.10 per ton.

"This plant has been in operation for five months and as yet no complaint has been made against this method of disposal of garbage. After 84 years of garbage disposal troubles it is believed that the city has found the proper solution of the disposal of garbage in a sanitary manner." Clinton H. Fisk, director of streets and sewers, has charge of garbage collection and disposal in St. Louis.

Sewer Maintenance in Dayton

Cleaning by flushing, by machine, by buckets, wheelbarrows, horse-drawn scoop and other cleaning methods. Sewer gases. Annual cost of sewer maintenance.

By Ivan E. Houk*

Keeping the city sewers open, clean, and in repair at all times so that they are always ready for the maximum test is one of the municipal problems which has been receiving a great deal of attention in Dayton during recent years.

THE SEWER SYSTEM

Dayton, a city of approximately 160,000 population, has 128 miles of storm sewers and 263 miles of sanitary sewers. Fortunately the separate system of construction was adopted when the first sewers were designed. Therefore there is but one comparatively short section of trunk line sewer in the city which carries both storm and sanitary sewage.

The storm sewers proper, leaving out of consideration the open channels, both natural and artificial, vary in size from 15 inches in diameter to an arched section about 25 feet wide and 15 feet high. With the exception of this one arched drain, the largest storm main in the city is a 12-foot circular sewer. While Dayton has several elliptical and egg-shaped sewers, they are all smaller than the 12-foot circular section. The sanitary sewers, which are all circular in section, vary in diameter from 8 to 42 inches. Although catch basin laterals are generally laid with 12-inch pipe, no main storm sewers are laid with less than 15-inch pipe.

Both storm and sanitary sewers are now built of vitrified pipe if the diameter does not exceed 24 inches, double strength for those larger than 15 inch. Three-foot lengths and deep and wide sockets are used in the sanitary lines in order to reduce the infiltration through the joints. Sewers larger than 24 inches in diameter are now built of monolithic concrete, but formerly were built of brick.

MAINTENANCE OF THE SYSTEM

The work of keeping the sewers in serviceable condition is handled by the Bureau of Sewer Maintenance, a part of the Division of Engineering which, in turn, is one of the subdivisions of the Department of Public Service. From 25 to 30 men are employed constantly in replacing broken catch basins, raising and lowering manhole castings to conform to changes in street and alley grades, cleaning catch basins and manholes, flushing and rodding sewers, cleaning sewers, replacing broken joints of pipe, relining sewers

*City Engineer of Dayton, Ohio.

with the cement gun, inspecting and operating flood gates, inspecting new house connections, and so forth. Cleaning the catch basins, manholes, and sewers, constitutes about 75 per cent of the work of this bureau. Joe Madigan, superintendent of sewers, who furnished the writer with the greater part of the material contained in this article, is in charge of the Bureau of Sewer Maintenance and is directly responsible for its high efficiency. The writer is city engineer and George F. Baker is director of public service.

The basins, manholes, and sewers are cleaned whenever they need cleaning—not at periodic intervals. Some sewers have to be cleaned two or three times a year; others only once in two or three years. Sometimes sufficient cleaning is obtained by thorough flushing. Other times it is necessary to use sewer cleaning machines. Sanitary sewers can generally be kept open by flushing, except in cases where they are obstructed by roots or where considerable quantities of sand and gravel have gotten in through some opening. Of course, temporary stoppages caused by rags, clothes, and so forth, are removed by rodding. Small storm sewers, especially the catch basin laterals, are also frequently opened by flushing.

CLEANING MACHINES

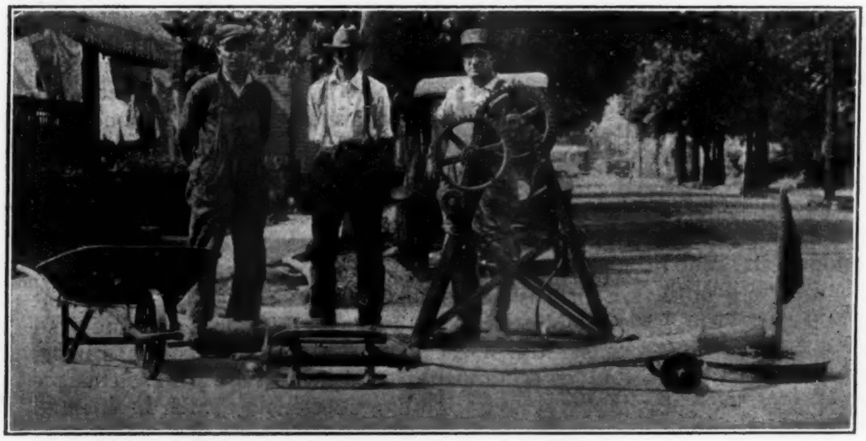
The turbine cleaning machine, a small hydraulic turbine with revolving knives, is used to open and clean the smaller sewers whenever satisfactory results cannot be obtained by flushing or rodding. This machine was purchased in December, 1919, at a cost of $1,515 f. o. b. Dayton, including accessories such as windlasses, braces, cables, clevises, clamps, sewer rods, both wooden and iron, forcing jack, pulleys, wrenches, extra knives, and in fact everything necessary for operation except the hose.

The machine itself consists of a small cylindrical barrel about 2 feet long, with four projecting arms near each end on which are mounted guides or runners which slide along the inside of the pipe. The turbine, with its revolving knives, is attached to the front end of the barrel; while the hose, leading to a hydrant which supplies the water under pressure, is attached to the rear end. A swivel clevis, mounted on the end of a rod projecting in front of the turbine, serves as a means of attaching a cable to the front of the machine. The machine is supplied with extra arms and knives of different size so that the turbine can be adjusted to fit all sizes of pipe from 6 to 20 inches in diameter. The 20-inch size can be used on sewers larger than 20 inches.

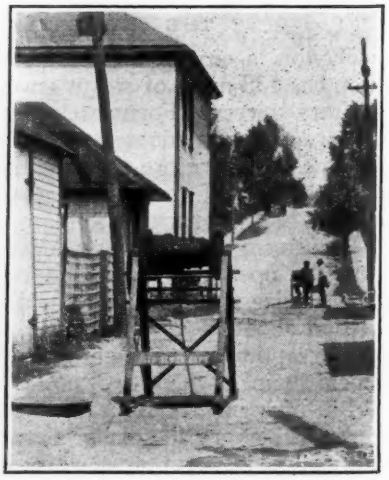
In operation, the wooden rods, which are 1¾ inches square by 3½ feet long, made of Oregon fir and fitted with malleable cast iron connections, are first pushed through the sewer from manhole to manhole. Then a small 3/16 inch galvanized cable is attached to the end of the rods and pulled through the sewer, drawing after it a ⅜ inch steel cable, the end of which is attached to the turbine, which has been lowered into the upstream manhole. A hose is attached to the turbine and a hydrant and a second cable attached to the rear end of the machine for use in pulling the machine back if necessary. The turbine is pulled slowly through the sewer by winding up the cable on the windlass at the downstream manhole, the knives revolving continuously as the turbine moves ahead, thus dislodging roots, cement, or other substances, and also washing the sides of the sewer thoroughly. As the turbine is pulled down grade, the water from it runs down the sewer ahead of the machine, thus carrying the detritus to the lower manhole, where it is caught by a small artificial dam placed at the downgrade side of the manhole, the water flowing over the top of the dam and leaving the solids on the floor of the manhole. The cables pass over pulleys, held in the manholes by suitable braces, to the drums on the windlasses above.

If the sewer is completely clogged so that the wooden rods cannot be gotten through from manhole to manhole, the turbine is placed in the lower manhole and forced upstream through the sewer by iron rods attached to the rear of the machine and pushed ahead by a worm geared jack.

Three men are required in this operation; one winds up the cable on the windlass, another feeds the hose into the manhole, and the third acts as a foreman and does whatever odd jobs may be required. The length of sewer they can clean in a day depends entirely on the particular conditions. If they can get the rods through without trouble, if the water pressure is sufficiently high, and if there is not too much sediment in the sewer, they can clean as much as three or four city blocks. The turbine has, in exceptional cases, been pulled through badly clogged sewers at the rate of 50 feet in 10 minutes,



TURBINE CLEANER CONNECTED TO HOSE READY FOR USE.



WINDLASS FOR OPERATING TURBINE.

but an average day's work is slightly less than two city blocks, or about 500 feet. Since the foreman is paid $4.50 per day and his helpers each $3.40, the average cost per foot on this basis is approximately 2.26 cents. During the year 1921, 100,000 feet of storm sewers and 12,000 feet of sanitary sewers were cleaned with this machine at a total cost of $2,644.20, or about 2.36 cents per foot of sewer. This cost does not include the hauling away of the detritus, which probably does not amount to as much as a half a cent per foot, so that the total cleaning cost would be less than 3 cents per foot. Sometimes as much as three or four cubic yards of sand and gravel are taken from one block of 15-inch storm sewer. Considerable time is always consumed in moving to the job, setting up the equipment ready for work, and dismantling it at night.

A water pressure of about 50 or 60 pounds per square inch is necessary in order for the turbine to work efficiently. At 60 pounds it is supposed to deliver 3 horse power to the knives, which are supposed to revolve at about the speed of an electric fan. If the pressure is much lower, it is necessary to pull the turbine through the sewer two or three times in order to clean it properly. In such cases trouble is also encountered due to clogging of the knives. On the other hand, if the pressure is too high the knives may revolve too rapidly, and, in case they strike some solid substance such as a piece of concrete, may be either flattened out or broken off. An extra supply of knives of all sizes should be kept on hand at all times.

Unless special emergency work interferes, we operate our turbine continuously during from 6 to 9 months of the year. When cold weather arrives the work is discontinued on account of the freezing of the hose and the general disagreeable conditions connected with working in the water at such times. In the spring, when the weather becomes warm enough, the work is resumed.

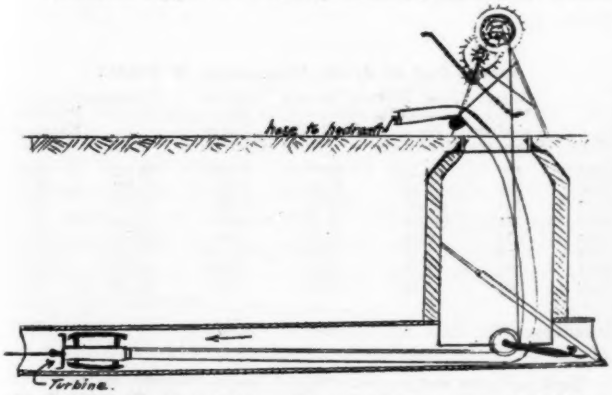
In our experience in operating this machine under practically all kinds of conditions only a few minor difficulties have been encountered, such as must be expected with any kind of machinery. Sometimes, when the pressure was low, we have had trouble in cutting through roots, but with pressures as high as 140 pounds we have cut through roots an inch in diameter, and through masses of roots so dense as to be water tight, through pieces of concrete, bricks, tin cans, and so forth.

Another type of sewer cleaning machine which Dayton has used is a bucket machine known as the Stewart sewer cleaning machine. We have machines of this make, one purchased in 1906, the other between 1908 and 1912, each costing $750. I understand that the later models have been much improved. We do not use these often now, and seldom on sewers larger than 24 inches in diameter. The bucket machines have the advantage over the turbine in that some of the finer material is always washed over the dam when the turbine is being used. The principal use we make of our bucket machines at present is to loan them to contractors to clean out new sewers that they have constructed.

OTHER CLEANING METHODS

Sewers which are large enough for men to enter are cleaned by the use of buckets, shovels, wheelbarrows, and windlasses. Sewers as small as 30 inches in diameter have been cleaned by crawling in them, scooping the sediment into small buckets, and dragging the buckets to the manholes, where they are lifted to the street by hand. If the sewers are large enough for the men to walk in, the debris is loaded on wheelbarrows, wheeled to the manholes, and then hoisted to the street level in large buckets by windlasses attached to substantial tripods. In the summer of 1922, 428 yards of gravel were removed from the Lorain avenue storm sewer by such methods at a total cost of $2,240, or approximately $5.23 per cubic yard, including the hauling away of the material. In the summer of 1916, 1,700 cubic yards of mud, sand, and gravel were removed from the Lorain avenue and Parrott street storm sewers by similar methods, but unfortunately no data on the cost of the work are available.

These two sewers, both built years ago, furnish examples of poor sewer design. The Lorain avenue sewer comes down from the comparatively high ground at the east edge of the city and changes abruptly from a grade of 2.70 per cent to one of 0.33 per cent, then to one of 0.18, and then to one of 0.12, the last continuing for a considerable distance. At the intersection of the 2.70 per cent and 0.33 per cent grades, which is at Parrott street, the section changes from a 5-foot brick to a 6.5-foot brick sewer and is joined by a 6.5 brick sewer from Parrott street. The Lorain avenue sewer is much overloaded



SEWER CLEANING APPARATUS USED AT DAYTON.


ROOTS FOUND IN AN 8-INCH SEWER.

while the Parrott street sewer is considerably underloaded. Consequently the water from the Lorain avenue sewer, which is loaded with mud and gravel from the unpaved streets to the east, backs into the Parrott street sewer and leaves a deposit of mud after each rain. The gravel is not carried into the Parrott street sewer because the velocity in that direction is not great enough to transport it, but is carried on down the Lorain avenue sewer and deposited in the section where the slope is only 0.12 per cent, where the velocity is naturally much reduced.

A few years ago a 300-foot section of a 9-foot circular storm sewer near the south edge of Dayton was cleaned by a horse hitched to a hand scoop. The section cleaned lies just above the outlet of the sewer, and the horse, which was blind, was led into the sewer, turned around, and led out again, loading the scoop and dragging it out of the sewer mouth.

Catch basins and manholes are cleaned by hand. An autoeductor was tried on the catch basins a few years ago and was found to work very well where the basins were filled with fine silt or mud. However, trouble was encountered when it was attempted to clean basins filled with sticks, twigs, and gravel, and by far the greater number of our basins become filled with such detritus rather than with fine material.

SEWER GASES

Sewer gases have not, thus far, required much consideration in Dayton. Complaints are frequently received from residents in different parts of the city saying that sewer gas is coming into their basements from the sewer, but upon investigation these cases invariably prove to be merely disagreeable odors from a cellar drain which has been connected to the sewer without being trapped and vented. Our maintenance men are working in the sewers throughout the city practically all the time, yet they have never encountered dangerous sewer gases except on one or two occasions when they were cleaning off the screens in front of the sewage pumps during a flood. We have had explosions in the sewers at times, but they have been due to leaks from the gas company's mains rather than to gases formed by decaying sewage.

Some trouble has been experienced with unpleasant odors escaping from the sewers into the streets. These have emanated from manholes at places where syphons have been constructed; from catch basins along our one combined sewer; from catch basins at intersections where by-passes have been installed from the sanitary to the storm sewers, to relieve the sanitary lines which are overtaxed by infiltration during heavy rains; and from manholes along the sewers leading away from packing plants. The undesirable conditions along the combined sewer have been relieved by replacing the old catch basins with new trap basins. Flap valves, installed in the by-passes, have achieved similar results. Nothing has thus far been done at the syphons, or below the packing plants, except to clean and disinfect the manholes and plug the openings in the manhole covers. However, we are considering installing vents to carry the foul air above the houses. These would be simply pipes running to the sides of the street and connecting with vertical pipes reaching several feet above the ground.

ANNUAL COST OF MAINTENANCE

The accompanying table gives, for each of the last eight years, the total length in miles of existing sewers in Dayton, sanitary and storm sewers being taken together, the total length cleaned by machinery, the total length cleaned by rodding and flushing, the total number of catch basins and inlets cleaned, the total cost of the sewer maintenance, and the annual maintenance cost per mile of existing sewers.

An inspection of the table shows that prior to 1919 the average maintenance cost per mile of existing sewers was about $58. In 1919 the cost more than doubled; and since that year the average cost has been about twice what it was before. The great increase in cost per mile in 1919 was due to the increase in wages and materials brought about by war conditions. In fact the scarcity of labor caused serious trouble during the year 1918, but owing to lack of funds, the difficulties were met by postponing some of the maintenance work until the following year rather than appropriating more money for that season's work. The large unit cost in 1920 was due to the great amount of repair work done that year with the cement gun. Several long stretches of sewers of from 6 to 9 feet in diameter, 5,241 feet in all, which were literally falling to pieces, were put in first class condition by relining with gunite and vitrified sewer liners. In some cases wire mesh was placed around the inside of the sewer and then filled and covered with gunite, thus producing a new reinforced concrete sewer inside the old section. The total cost of the cement gun repair work amounted to $15,000, so that the routine maintenance operations, such as make up the total cost given for the other years, was only $46,688, or $124.83 per mile. If this figure is inserted in the table for the year 1920 the maintenance costs per mile will show a gradual decrease since 1919.

It will be noticed that the average number of catch basins and inlets cleaned per year is 4,947, or nearly 5,000. Unfortunately accurate figures regarding the total number of basins and inlets existing in the city during each year are not available. The total number of catch basins existing at present is about 1,920, and the total number of inlets about 2,930, giving a combined total of 4,850. Consequently the total number of basins and inlets in Dayton are cleaned an average of once a year. Since it is necessary to clean the inlets only when they become clogged with sticks or some other debris, it seems likely that the basins are cleaned an average of at least twice each year.

Annual Cost of Sewer Maintenance in Dayton

Year	Total Miles Existing Sewers*	Total Miles of Sewers Cleaned: By Machinery	Total Miles of Sewers Cleaned: By Rod'g or Flush.	Basins and Inlets Cleaned	Maintenance Cost: Total	Maintenance Cost: Per Mile Existing Sewers
1915	339	—	56**	7,000	20,142	59.42
1916	348	1.24	70.29	5,480	19.551	56.18
1917	364	none	102.02	4,260	19,888	54.64
1918	371	none	29.83	2,619	22,810	61.48
1919	372	0.28	25.28	2,682	48.836	131.28
1920	374	3.77	24.50	5,280	61,688†	164.94
1921	381	21.21	26.04	7,500	45,202	118.64
1922	391	3.52	29.53	4,752	38,467	98.38
Averages			45.44	4,947		93.12

*Both sanitary and storm. **Total length cleaned, no record of length cleaned by machinery. †This includes $15,000 spent in repairing sewers with gunite.

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A. PRESCOTT FOLWELL, Editor

CONTENTS

Convention Papers

For more than twenty-five years the writer has been attending conventions of societies that specialize in the construction and operation of public works—water works, sewers, highways, etc.—and has more or less faithfully sat through the sessions devoted to the reading and discussion of papers. And he has reached the conclusion that fully half that time was wasted.

Many, perhaps the majority, of the papers read at conventions are entirely unsuitable for that purpose, although as contributions to technical literature they may be excellent. We believe that the opportunity offered by the assemblage of numbers of specialists in a given branch of knowledge should not be wasted by asking them to listen to descriptions that could just as well—often better—be read by them at their homes; but advantage should be taken of the opportunity for comparing experiences and especially for discussing, face-to-face, controverted points of theory and practice with a view to reaching conclusions, clarifying ideas or broadcasting important developments.

In our opinion a paper, the reading of which is followed by applause only, without any discussion, might better have been read by the members at their homes. For only a few hours once a year these men have an opportunity of becoming acquainted, of personal interchange of ideas, and of receiving inspiration for more elevated professional ideals, and they should not be asked to devote these precious moments to the mere acquiring of more or less unimportant information that could equally well occupy leisure hours at their homes.

Papers that would serve their purpose equally well if published in the society's journal or in technical or trade periodicals have no place on a convention program.

Pumping Plants and Coal Shortages

A considerable part of the public water works plants of the country are absolutely dependent upon pumping in furnishing water to their communities and upon fuel for operating their pumps. Except in extremely cold weather, water is more essential to the health and life of human beings than is heat, and is much more so than trolley transportation or light. It would seem, therefore, that water should head the list of preferred consumers in the allotment of coal.

It seems probable, but not yet certain, that this winter will not see a repetition of the fuel scarcity of last, but in view of the importance of water supplied to communities no chances should be taken, but water commissioners and companies should press their claims for preference in the allotment and early delivery of coal.

In this connection it might be well to consider the substitution of other fuel, such as oil, and make detail plans ready for instant application if necessary. This was done last year by the Water Division of St. Louis, which changed its stoker furnaces at all pumping stations from coal to oil burning in 24 hours. A floor of fire brick was laid on top of the chain grates, flat-spray burners were installed, and the plants operated on oil for about three months. In this case the cost of oil was greater than that of coal per pound of steam evaporated, but by using oil the handling of coal and ashes is eliminated, the heat is more readily adjustable to varying demands, and there are other advantages. Only about half as much weight of oil as of coal would be required, which would be an advantage from the transportation point of view.

In view of the annually recurring threat of coal shortage it would seem to be profitable for water works superintendents to study carefully the substitution of oil for coal in their plants as a temporary measure, or even as a permanent one.

Oil Pollution of Navigable Waters

A conference is to be held on October 1st, 2nd and 3rd at Haddon Hall, Atlantic City, New Jersey, to discuss the growing nuisance and menace of the oil pollution of the navigable waters of the country and, in fact, of all civilized countries during the past few years. The conference is called by the National Coast Anti-Pollution League with a view to uniting against the oil pollution of coastal waters all the interests concerned, these including public health officials, port authorities, shell fish industries, hotel and resort owners, sportsmen and game protective associations, yacht clubs, fire underwriters, ship owners, water supply commissions and others. The remedy suggested is the passage of federal, state and municipal legislation prohibiting the discharge of oil, and international agreements to the same end; also the use by steamships of proper devices for separating oil refuse from waste water, or the provision of oil harbors or tanks.

Dedication of Don Pedro Dam

Another large dam to be used for irrigation purposes was dedicated on June 26th near Modesto, California, built by the Modesto and Turlock Irrigation Districts. In addition to furnishing water for irrigation, a considerable amount of electric energy will be generated by means of the dam.

This dam is known as the "Don Pedro." It is 283 feet high above the stream bed and 1,040 feet long, and will impound 290,000 acre-feet of water in a reservoir 14 miles long and covering 5 square miles. The dam is 16 feet wide at the top and 177 feet at the base and contains 281-550 cubic yards of concrte.

The Lighting of City Streets*

Considers especially secondary thoroughfares and residence streets. Location of light units and foliage interference.

Originally the function of street lighting was the prevention of crime, and as late as the eighteenth century it was dangerous for a person to travel the streets of almost any large city after nightfall without a bodyguard. Good street lighting has done away with this undesirable condition, so much so, in fact, that one is likely to forget the fundamental purpose of street lighting.

Another reason for street lighting which has always been more or less apparent is the facilitation of traffic. Especially is this true today when, with the ever-increasing amount of high-speed automobile driving, good illumination becomes more and more essential in the reduction of accidents. Statistics compiled as a result of exhaustive surveys indicate that a tremendous number of automobile accidents occurring at night are directly traceable to insufficient illumination.

The electrical industry has made an exhaustive study of the problems presented by satisfactory street lighting, and this has resulted in the improvement of the lamps designed for the purpose and the standards supporting the lamps. Scientific illumination of streets is now possible with a comparatively small outlay of money on the part of the municipality, and will at the same time be a most profitable investment from every angle. R. E. Greiner and Earl A. Anderson, two experts in the problems of street lighting, have done much constructive work in this field and much of the material contained herein is the result of their investigations.

While the fundamental reason for street lighting is the prevention of crime and accident, it has an equally important part in contributing to the comfort and convenience of the community. A satisfactory street lighting system not only makes possible the traversing of sidewalks and streets but effectively reveals inequalities in sidewalks and paving surfaces and makes walking both pleasant and safe. Even in less frequented locations a printed or written address is readable without striking a match; street signs are well enough lighted to eliminate the necessity of stopping to decipher them; house numbers are visible at a reasonable distance, and passing friends may be recognized on the streets in any part of the city. The goal of the street lighting plan, which is reasonably attainable without an undue expenditure, should be that the normal daylight activities on the streets may proceed at night practically without delay or increased difficulty.

In considering a plan of street lighting for a city, it is necessary to observe carefully the different requirements for each class of street to the end that the most efficient result possible may be obtained from the expenditure. The principal thoroughfares leading outward from the center of the city carry much traffic of a high-speed nature and must be lighted accordingly. In the residential streets, which do not carry through traffic to any great extent, requirements of illumination from the standpoint of traffic are, of course, much less severe. In some outlying districts appropriation allowances sometimes make it necessary to reduce the lighting to a system of small marker lights for corners only.

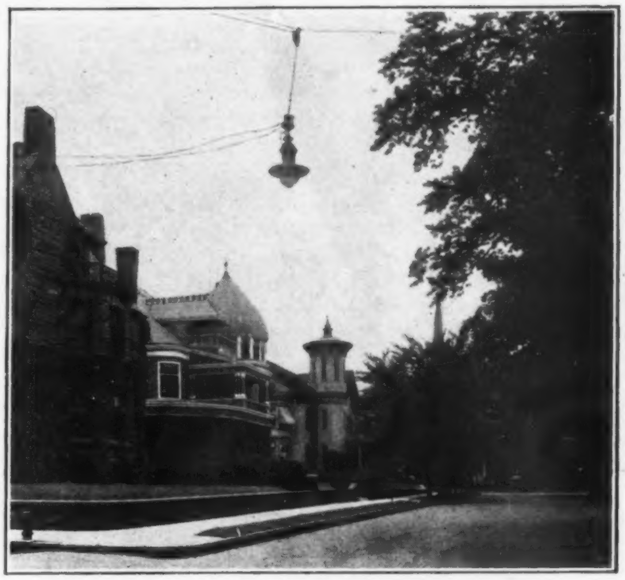
The thoroughfares leading out from the business center of the city have developed severe requirements for lighting under the new conditions of transportation. These streets carry high-speed traffic and are the location of a large percentage of street accidents, particularly at night in those cases where a proper provision for lighting has not been made. A fair provision for thoroughfares outside of the business

*Furnished through the courtesy of the Electrical Industries' Joint Committee for Business Development.

district is an arrangement of lamps, 600, 1000 or 1500 candlepower spaced from 150 to 250 feet apart, or at 300 feet as a maximum. If the street is very wide it may be necessary to consider each side as a separate street and provide lighting accordingly. The mounting height should be 20 or 25 feet in order to remove the bright light sources from the line of vision and to obtain a better spread of illumination. In the past, especially where there were wooden poles on the street, it has been common practice to use a lighting fixture suspended from a mast arm. This has the virtue of bringing the lamp over the street surface, causing the light rays to clear low-hanging foliage of adjacent trees. Bringing the lamp over the pavement also increases the possibilities of seeing objects by silhouette against the bright spot of light beneath the lamp or against the bright streak or glint reflections from the pavement. This is an especial advantage in the case of much traveled streets, which soon become blackened from oil but polished by wear and have a glossy surface when wet. Under these conditions a very large dependence must be placed upon seeing objects in silhouette against the glint from the pavement on account of the low level of general illumination.

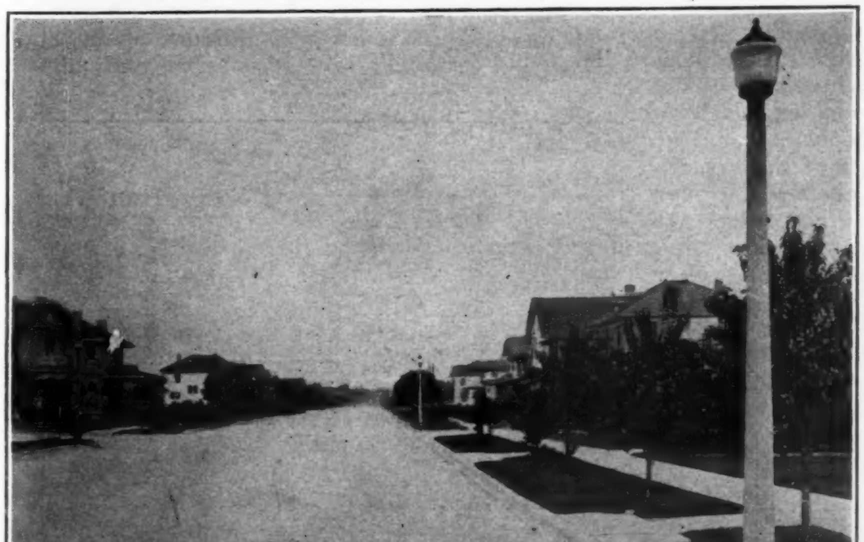
Recent designs of street lighting equipment for thoroughfares and boulevards have shown the results of efforts to retain the efficiency of light distribution of this type of lighting and at the same time to obtain a construction which would add to the appearance of the street.

Where residence streets carry a large amount of through traffic they are in effect thoroughfares and should be lighted as such. In every city, however, there is a large percentage of street mileage not used for through travel and therefore not subjected to a large amount of high-speed traffic. Even in these streets, however, sufficient illumination must be provided to enable one to see objects and obstructions in the pavement when traveling at a moderate rate of speed. Illumination for sidewalks must also be provided of sufficient intensity to provide comfortable walking, and which does not leave such dark shadows behind tree trunks as might provide hiding places for footpads.



THIS FORM OF SUSPENSION ELIMINATES FOLIAGE OBSTRUCTION.
A 600 C. P., 20 Ampere Mazda Lamp.

Residence streets are usually well provided with trees, and unless the lamp in such cases is suspended over the center of the street, it is often necessary, to avoid a large loss of light, to use somewhat lower mounting heights than would be desirable on streets without trees. However, when 250-candlepower lamps are used they may be mounted as low as 15 feet above the curb without undue glare provided the light is properly diffused and directed. When larger lamps are used and at wider spaces, heights of 18 to 20 feet are considered preferable practice. In this matter of adequate height, the ordinary wood-pole bracket installations have been better than many systems of ornamental standards supplied from underground wiring. Some of these systems have used globes mounted on upright posts only 10 or 11 feet in height, and while tree foliage is successfully avoided the units are likely to prove very glaring in the eyes of drivers, pedestrians or of people on porches. Furthermore, a very close spacing must be adopted if all sections of the street are to be illuminated. Particularly on a curved road, glare from lamps placed too low may so interfere with vision that the lamps may actually become a source of danger to automobile drivers. In view of this, there is a tendency in recently installed systems to adopt a minimum height of



THOROUGHFARE AT HOUSTON, TEX., LIGHTED BY UNITS SPACED ABOUT 150 FEET APART, STAGGERED, AND 15 FEET ABOVE STREET SURFACE.

USED ON ONE SIDE OF STREET ONLY, SO MOUNTED AS TO PROVIDE SUFFICIENT LIGHT FOR BOTH SIDES.

15 feet for ornamental posts on residential streets. In addition, ornamental bracket designs have been developed which bring the lamp 16 feet or more above the street and with a bracket length of 4 or 5 feet to assist in clearing the foliage. When these equipments carry well designed refractor fixtures, the light utilization is as great as from the efficient but often unsightly wood-pole brackets.

The spacing of the lamps on residential streets varies greatly. Where overhead wood-pole distribution is used and the appropriation allowance is limited, spacings of 300 feet may be used to give fair lighting provided there are no trees to obstruct the spread of light. On the other hand, spacings of 100 feet or even less are not uncommon for underground distribution supplying ornamental units. Unless the interference from trees is excessive, spacings of 150 to 200 feet are found satisfactory. The lamps are usually staggered to eliminate as far as possible all tree-trunk shadows.

COST OF ADEQUATE STREET LIGHTING

A recent survey showed that fifteen years ago approximately 5.4 cents out of each dollar of municipal taxes was the average amount expended for street lighting in cities of 30,000 population or larger in the United States. In the face of the need for much better lighting, the amount allotteed for street lighting for the same cities in 1919 had fallen to an average of 3.8 cents. In an article commenting upon this relatively small expenditure for this essential public service, one author reported that the average per capita expenditure in cities is only about 70 cents annually for street lighting. The highest reported was $4.81 per capita, and in fifty of the best illuminated cities there was an average of $2.04 per capita.

It probably is not sufficient to compare street lighting expenditures on the basis of population alone, since in cities having the same population there may be considerable difference in the number of miles of improved streets. Possibly a fairer method of comparing street lighting appropriations is to base the computation on the basis of paved streets. But even on this basis there are several variables which should have weight. Some of these are the layout of the city, the width of streets and intersections, the amount of foliage, the character of street paving, whether current is distributed overhead or underground, and the local cost of labor and materials entering into construction. The following tabulation, however, indicates the order of annual cost per running foot of street:

Class of Streets	Annual Cost Per Foot of Street
Business district	$1.00 to $4.00
Thoroughfares, mfg. dists., blvds.	.25 " 1.00
Residential streets	.15 " .60
Outlying districts and alleys	.05 " .20

The lower range of figures applies to systems involving a minimum outlay for installation, and in general providing minimum levels of illumination. The upper range of expenditure in most cases permits an adequate installation consisting of underground distribution supplying ornamental lamp standards of substantial design and properly placed to obtain maximum effectiveness of illumination.

The initial investment for installation of circuits and equipment is a factor which affects the design of street lighting in a greater measure than it does interior lighting. Especially where the service to the lamp is carried underground, as is becoming more and more the practice for new installations in progressive cities, the fixed charges on the investment for equipment may actually form half the annual cost of the system. The actual cost of installing the ducts and cables, the cost of lighting standard and fixture, and some of the costs of maintenance, such as cleaning and repair to equipment, increase but little for the larger sizes of lamps as compared with smaller. There is consequently a distinct economy in cost per unit of light by adopting the larger lamp sizes.

In view of the insufficiency of municipal appropriations, it became quite common several years ago for individual groups of property owners to install sections of improved street lighting with ornamental equipment at private expense. Because of the difficulty, however, of insuring a continuance of proper

UNIT SUSPENDED FROM MAST ARM BRINGS LIGHT OVER SURFACE OF PAVEMENT.

G. E. Novalux, two units with prismatic refractors.

maintenance under this plan, and also because of the recognition of the importance of this lighting as a municipal improvement, present practice is very distinctly in the direction of having cities handle contracts for the installation and operation of all street lighting. Particularly in business districts, the city may assume the entire cost of the system in view of the benefit accruing to the city as a whole. In other cases a large part of the cost of special lighting may be charged back to abutting property under the laws in many States, which permit the establishment of special improvement districts in which assessments are made for the street lighting in the same manner as for the paving and other necessary street improvements.

Hill-to-Hill Bridge*

Continuation of description of construction methods employed in the construction, now nearing completion, of a six-thousand-foot viaduct at Bethlehem, Pennsylvania, described in the July issue.

FORMS AND FALSEWORK

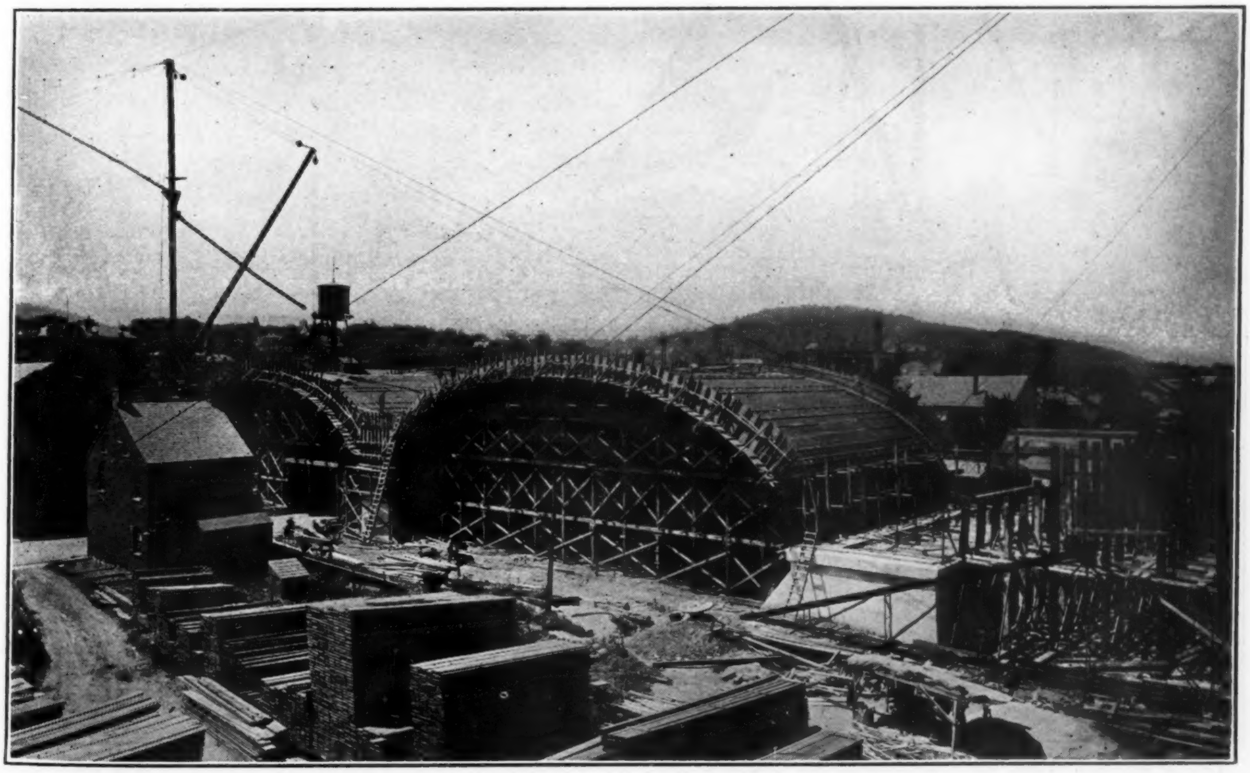
The 1¾-inch transverse lagging planks for the arch spans of the main bridge were nailed to 27 lines of 3x12-inch bows breaking joints on the center lines of 8x12-inch transverse caps from about 6 to 8 feet apart. At the ends of the spans these caps were generally supported on transverse framed falsework bents and in the centers of the spans they were carried on short vertical posts that were seated with wedge adjustment on 10 lines of longitudal stringer caps scabbed to the vertical posts of the falsework bents.

*Concluded from page 253.

On the river piers small reinforced concrete brackets integral with the pier masonry were cast on the sides of the piers near the water level and firmly anchored to the pier masonry to support the lower ends of the vertical posts in the end bents of the false work. These bents, together with one or two adjacent bents that supported the haunches of the arch and the umbrella tops of the piers, were secured by permanent, horizontal anchor rods imbedded in the pier concrete and provided with end couplings close to the surface of the concrete which permitted the exterior extension to be removed and the holes pointed up after the erection had been completed.

Each of the 129-foot spans, 17-18 and 18-19 on the Main street branch of the bridge, has nineteen transverse bents, generally about 7½ feet apart. Each bent has ten 10x10-inch vertical posts, proportioned for 20,000-pound loads and assembled with 2x10-inch longitudinal and transverse diagonals and 4x10-inch scabs secured by ¾-inch bolts. Over Water street and over Monocacy creek, near the centers of their respective spans, open panels 15 feet wide in the lower tier of falsework, were spanned by 15-inch I-beams supporting the upper stories of the false-work. The mud sills were carried on 12 x 30-inch concrete footings.

The falsework for the 107-foot span, 6-7 of the main bridge, was supported in the center on a pier of the old bridge, formerly occupying the site of the present structure, and on both sides of the pier it was supported on pile and framed bents. The adjacent 107-foot span, 5-6, was similarly supported.



FRAMED FALSEWORK, CENTERING AND LAGGING FOR 146-FOOT ARCH SPANS.

The 48-foot 10-inch span, 2-3, over two railroad tracks, has fourteen reinforced concrete girders, the forms for which were supported at the ends on framed falsework bents and intermediately on 10x10-inch transverse sills wedged up on the top flanges of 14 lines of 30-inch I-beams spanning a 32-foot 8-inch train clearance 18 feet high.

The sides and bottoms of the forms were generally made with 2x4 and 2x6-inch bevelled-edge planks except for the spandrel walls, which were of 1⅞-inch tongue and groove boards with 2x6-inch verticals 15 inches apart on centers and pairs of 3x6-inch waling pieces 3 feet apart vertically. The forms were braced when convenient by exterior inclined struts. For the arch ring they were braced to the projecting caps of the falsework, and were tied together by horizontal wires clearing the tops of the forms and extending across the full width of the bridge.

Pier forms and spandrel wall forms were tied with ⅝-inch permanent tension bolts having couplings at each end, permitting the removal of the end sections when the forms were stripped. The form bolts were all well oiled, to facilitate removal, and were twisted 180 degrees 12 hours after the form was concreted. The number of ties in the pier forms were proportioned to the height of concrete, sometimes as great as 25 feet, that was poured at once. The concrete in the spandrel wall sections was completed at a single pouring.

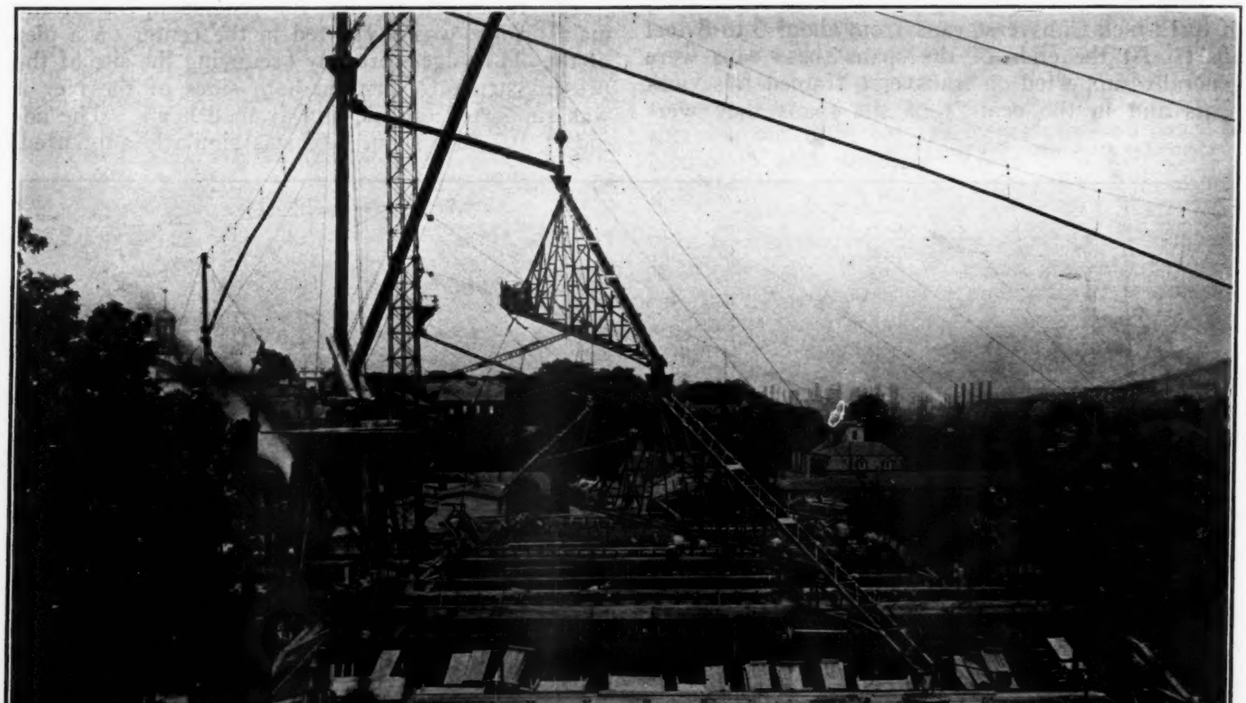
The fourth tier of ties from the bottom were anchored by permanent wire diagonal ties from the ends to resist floating by the buoyancy of the wet concrete. The ends of the lower tie rods were connected by very flat, transverse diagonals to anchor eyes imbedded in the arch rings to provide for adjusting and maintaining alignment.

The thicknesses of the arch rings at the ends were so great, and the pier forms were so large, that workmen entered the latter and very carefully spaded and rammed the wet concrete around the numerous reinforcement bars in the umbrella tops of the piers. The largest of these tops contained about 550 yards of concrete, which was continuously poured in one 24-hour operation. The end sections of the arch ring were concreted with top forms.

The permanent horizontal anchor rods in the pier masonry had end nuts bearing on vertical angles, built into the pier and arch rib concrete, which were secured by long, inclined back stay rods with nut bearings on the anchor plates at the lower ends.

The falsework, centering and vertical forms were accurately calculated and fully detailed on more than thirty-five large sheets of drawings, made for the contractors by Jackson & Moreland, Boston.

Concreting was commenced Dec. 14, 1921, and the work was discontinued on account of cold weather Jan. 11, 1922. It was resumed March 15, 1922. On July 1st, 1923 the work was about 75% com-



ARCH FORMS AND REINFORCEMENT READY FOR CONCRETING COMMENCED AT PIERS. BALANCED CANTILEVER CHUTES SUSPENDED FROM TOWER DERRICK.

pleted; all the piers except No. 2 were completed and 15 of the arches had been concreted.

PROGRESS AND QUANTITIES

The maximum amount of excavation made in one month was 9,480 yards. The maximum amount of concrete placed continuously in one form was 944 yards, spouted through chutes in 36 hours; the maximum quantity placed continuously in one form by buckets was 958 yards in 24 hours; the maximum quantity placed in one month was 8,723 yards.

The principal total quantities involved are: 64,000 yards of excavation; 100,000 yards of concrete; 34,550 yards of backfill; 49,400 yards of arch fill and ramp fill; 160,000 barrels of Pennsylvania Portland cement; 90,000 yards of broken stone; 60,000 yards of sand; 1,700 tons of reinforcement steel; 1,650 tons of structural steel; 500 tons of steel trolley tracks; 23,300 square feet of granite pavement; 230,000 square feet of 2-ply waterproofing; 180,000 lineal feet of electric conduit; 133 bronze lamps; 24,000 square feet of steel sheet piles; 2,000,000 feet of wooden foundation piles.

Great care was taken to use only the highest quality of cement. This was manufactured to standard specifications by the Pennsylvania Cement Company, inspected and tested at the mill and delivered from concrete bins to the automobile trucks that conveyed it to the bridge site. Concrete test cylinders are made almost daily.

The force employed June 1st 1923 aggregated 10 office men, 13 engineers and assistant engineers, 4 men on steel details, 17 chauffeurs and garage men, 15 mechanical and power men, 12 storeyard men, 20 reinforcement steel men, 84 carpenters, 66 carpenter's laborers, 50 concrete men, 20 concrete laborers, 28 quarry men, and about 60 other employees and 15 executives.

The bridge is being built for a lump sum price of $2,568,000.

IMPORTANT ITEMS OF PLANT AND EQUIPMENT

There were installed on this job, four Smith mixers with Troy vertical engines, automatic batch meters and watertanks, measuring buckets and charging hoppers; 12 Lidgerwood, 5 Clyde and 3 Lambert hoisting engines; 11 Lidgerwood and 3 Mead Morrison swinging engines; 6-1 yard Hayward orange-peel buckets, 3 Hayward, 1 Williams and 1 Owen clam shell buckets; 5 Kingsford, 2 Swaby, and 3 Lawrence centrifugal, motor-driven pumps, 4 of them with 10-inch suction pipes; 6 Cameron, 1 Buffalo duplex, 1 Worthington simplex, 1 Morris centrifugal and 1 Gould centrifugal steam-driven pumps; 5 Godfrey-Keeler, 1 Donegan & Swift and locomotive type steam boilers; 8 Burke, 1 Northwestern Manufacturing Co.'s, 2 Westinghouse, 5 General Electric, 1 Valley Electric, 1 Mechanical Appliance Co.'s and I Emerson Electric Motors of 3 to 100 horsepower; 13 stiffleg and 4 guy derricks with 45 to 80-foot booms; 5 McKiernan-Terry and 1 Vulcan pile hammers, 4 Ingersoll-Rand and 11 McKiernan-Terry sheeting hammers; 13 Ingersoll-Rand and 1 Cleveland rock drills; 2 Ingersoll-Rand gasoline driven and 1 Chicago Pneumatic Tool Co.'s steam driven air compressors; 1 Keystone steam drilling machine; 1 Osgood and 1 Marion steam shovels; 2 Gates and 1 Blake stone crushers; 19 stone screens, 26 Stuebner 1-yard and 1½-yard self righting dump buckets and 9 botton dump 1-yard concrete buckets; 2 cement bag cleaners, one of then driven by a ¾ horsepower electric motor; 2 cutting and welding torches; 1 Brownhoist locomotive crane with 52 foot boom; 1 Austin-Western Road Machinery Company's 12-ton gasoline road roller; 20 Pierce Arrow 5-ton dump trucks; 2 platform trucks, 2 trailers and one Stewart ¾-ton service truck; besides miscellaneous equipment and hand tools.

Water Power Development in North Carolina

Only a day or two after writing the editorial published in our June issue urging the advantage of cooperation between public officials and private individuals and companies, we received information of another instance of this advantageous cooperation, this time between state officials and public service corporations.

"The Southern Appalachian Water Power Conference is an organization of state commissions, public utility companies, engineers, bankers, industrial or commercial interests and individuals concerned with the development, operation, regulation and utilization of power projects and industries dependent upon them." Among the officials may be named Joseph Hyde Pratt, Director of the State Geological and Economic Survey, as president, a vice-president of the Southern Railway as vice-president, an hydraulic engineer as secretary, and the hydraulic engineer for the State Geological Survey as treasurer; while the executive committee includes a state geologist and a state forester, and officials of the Seaboard Air Line Railway, the Carolina Power and Light Company, the Columbia Railway and Navigation Company and the Georgia Railway and Power Company.

This conference aims to effect a more harmonious relation between public utilities, public service regulatory bodies, and the general public, establishing a bureau of public relations for this purpose. This bureau will prepare and disseminate accurate information concerning the development and availibility of power. It will, when requested, act as mediator in disputes when these do not relate to rates.

It also proposes to establish a bureau of industrial development to furnish accurate information to industrial and commercial organizations, engineers, bankers, etc., obtaining this information by thorough investigation of the water powers, forests and other natural resources of the region, utilizing such information as had already been obtained by State Geological Surveys, conservation commissions and others. It will aim to serve as a general accurate source of information relative to the proper exploitation of the great natural resources of the South.

The conference also proposes to establish a bureau of research for compiling information relating to rainfall, run-off, power problems, natural resources, etc., now widely scattered, and carrying on investigations suggested by the conference.

It certainly gives promise of more amicable and mutually profitable relations between the public and

public service corporations when representatives of such corporations and of state governments cooperate in the development of public utilities that are of such vital importance to both. It offers hope that before long we will see municipal public service corporations and the taxpayers of cities meet each other in a friendly spirit of cooperation for the development of service which shall be satisfactory to the citizens and at the same time will yield to the corporations an income adequate to attract the necessary capital but recognized by the users of the service as being no greater than is justifiable.

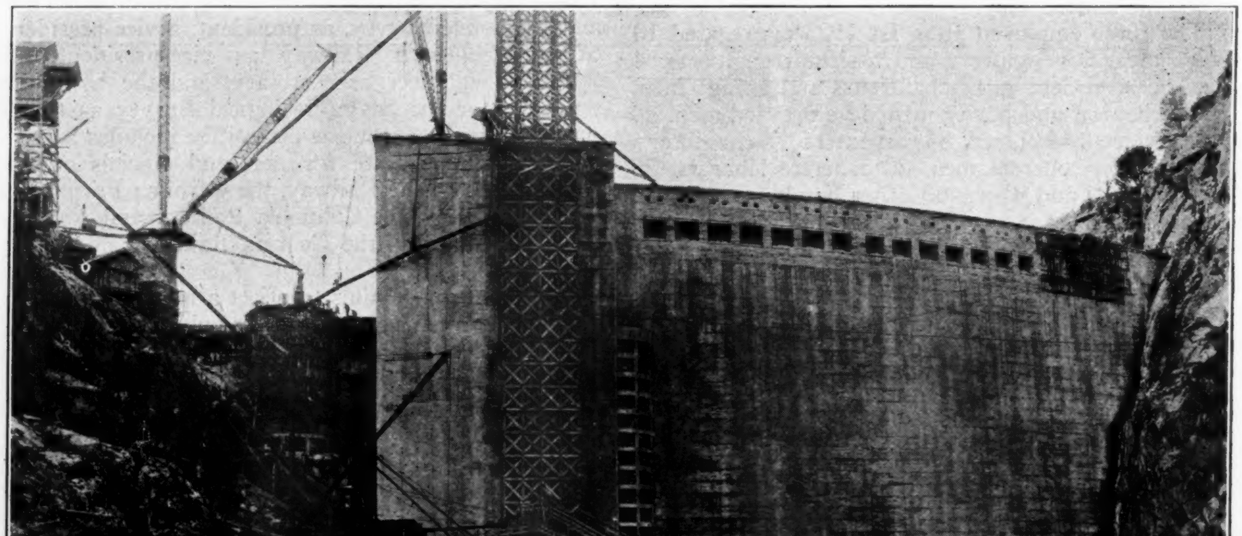
The Hetch-Hetchy Dam Completed

This dam, of national interest to engineers, has been officially named the O'Shaughnessy Dam. Its completion makes a prominent step in the consummation of San Francisco's ambitious program.

By CHARLES W. GEIGER

The City of San Francisco has just completed at a cost of $5,500,000 one of the largest masonry dams in the world, in connection with its Hetch Hetchy water and power project. Descriptions of this project have been given from time to time in *Public Works*. (See Sept. 21, 1918; March 6, 13 and 20, May 8 and 22, and June 12, 1920; July 8, 15 and 22, 1922). Now that it has been completed a brief description of the dam may be appropriate.

The structure is built in the shape of an arch with a 700-foot radius. It is 298 feet thick at the bottom. The foundation is 114 feet below stream bed and the crest is 227 feet above, making a total height from the foundation to the crest of 341 feet. The foundation is spread out with an offset 80 feet wide at the stream bed to provide for an addition in the



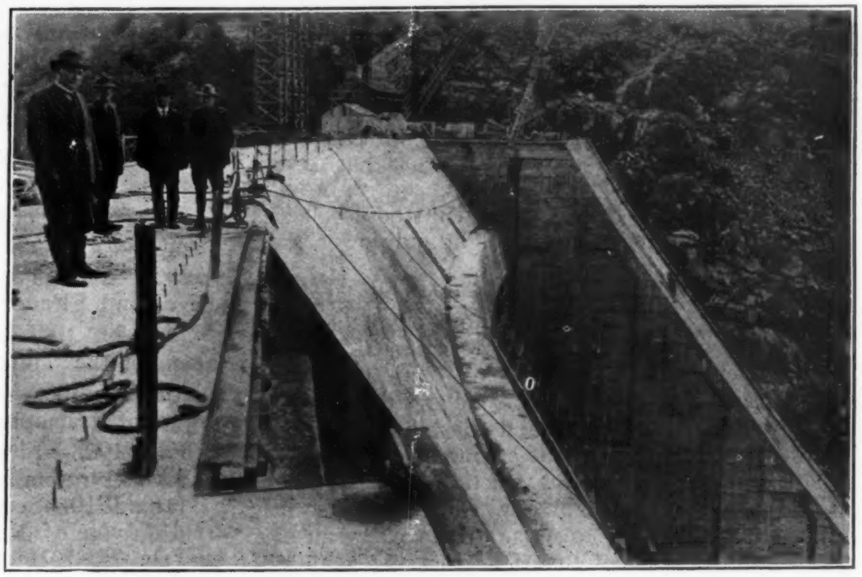
UP-STREAM FACE OF O'SHAUGHNESSY DAM.
Showing reinforced concrete screen racks which are built into towers attached to and constituting part of the dam.

future, which will permit another 85½ feet of height to the structure without excavating the stream bed. This addition will make it one of the largest masonry dams ever built. The dam is built with a siphon spillway, which will automatically hold the water level of the full reservoir constant within narrow limits. A roadway 15 feet wide runs along the crest of the dam, over the spillway and provides convenient transportation from one side to the other of the river.

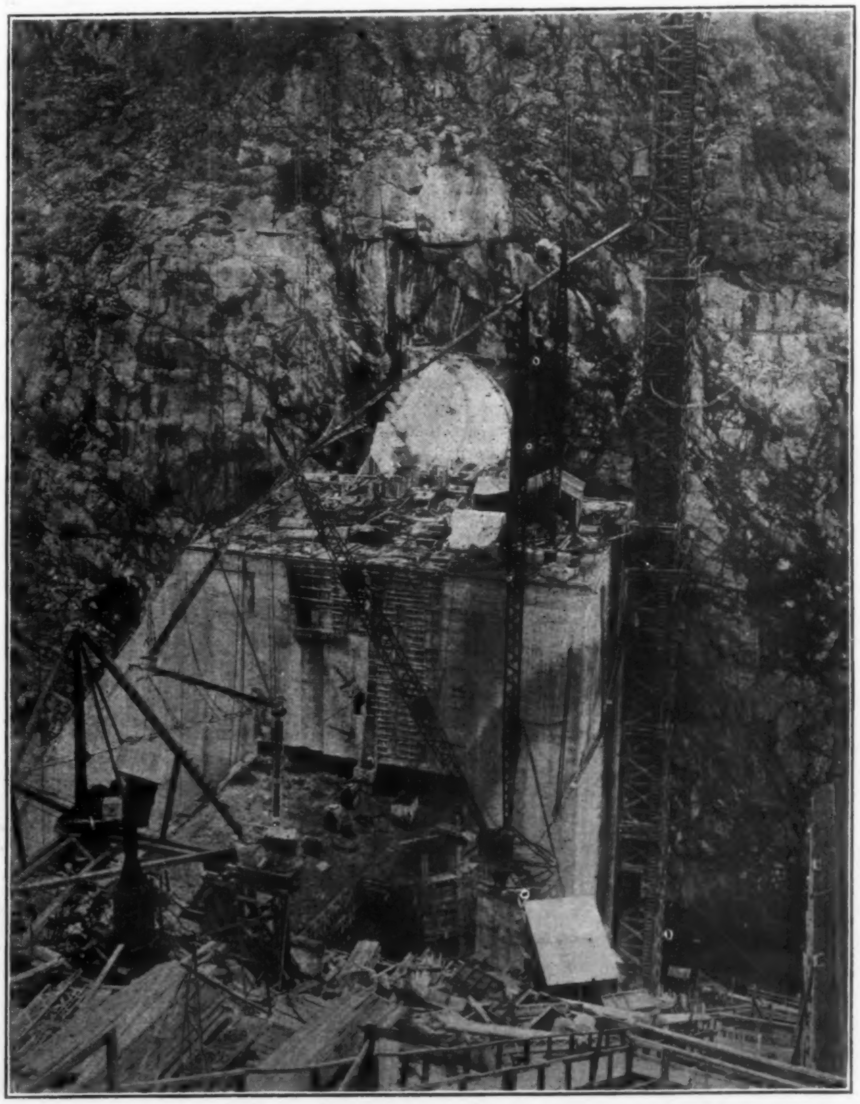
Twelve needle valves, six of them three feet and six five feet in diameter, are used to regulate the discharge of water from the reservoir as desired. The needle valves are backed by hydraulically operated slide gates, and these again by concrete shutters, in order to allow inspection and repair while the reservoir is full.

The irrigationists of Turlock and Modesto have 250,000 acres of farming lands on the lower levels of the Tuolumne River and under the terms of the Hetch Hetchy grant, under which San Francisco is operating, it must allow the natural flow of the water in the stream below the dam up to 2,350 second feet for the irrigationists' use, excess of this being stored for the city's use. Frequently enough floods come down in two weeks, during May and June, to fill the Hetch Hetchy reservoir.

During ordinary levels of the reservoir the water is allowed to flow through the six 5-foot gates, which are placed in batteries of two, at three different levels. Over two years was devoted by the city's engineers to making a study of the best kind of outlet gates to use for this work and, as a result, it was determined to use balanced valves with auxiliary sluice gates and drops to give extra control



CREST AND DOWN-STREAM FACE OF DAM.
City Engineer O'Shaughnessy at the extreme left.



CONSTRUCTION JOINT OF DAM, FROM SOUTH ABUTMENT.
Two arrows in center of picture point to gallery and stairway built in the dam.

during repair. All valves are protected from logs and brush by precast reinforced concrete screen racks, which are built into towers attached to and constituting part of the upstream face of the dam.

An elaborate system of stairways and galleries built in the dam allows complete inspection of the interior of the dam at all times. In order to provide electric current for lights installed in these galleries and for any motors, an electric light and power plant is being installed in the dam.

In preparing the foundation of the dam, large pot holes were disclosed in the bottom of the excavation, which were formed by water action of cascades from ancient glaciers, millions of years ago, which wore circular caverns in the solid granite. It was only necessary to use a sand blast and scrubbing brushes to clean the ancient surfaces to make a desirable contact for new construction.

The name "O'Shaughnessy Dam" has recently been officially given to this structure, because it stands as a monument to the engineering genuis of M. M. O'Shaughnessy, San Francisco's city engineer.

CONSTRUCTION PROCEDURE

The contractors built two camps, one at the bench 400 feet above the floor of the valley, about half a mile above the dam. Rock for the construction was procured from the debris of Falls creek, a mile and a half east of the dam. An excellent bed of sand was found three miles east of the dam.

A railway track was built by the contractors and seven locomotives used for hauling sand and rock materials to the crushers. Stock piles were located here and the materials hauled down to the dam by trains and dumped into separate bunkers, from which it was hoisted by belts up to the mixers, at the base of a tower 350 feet high.

Cement was drawn from a 16,000 barrel storage bunker built on the side of the mountain between the dam and the railway. Cement was hauled to the bunker in bulk in box cars on the railway, thus eliminating waste of time and cement in handling sacks.

This cement was unloaded into the storage bins at the dam site by small slip scrapers pulled by electric motors. The men doing the unloading wore gas masks to prevent the inhaling of dust.

CHRONOLOGY OF THE HETCH HETCHY SUPPLY

1901—Upper Tuolumne River chosen by San Francisco municipal authorities as source of San Francisco's future water supply.

1901—Filings by Mayor Phelan of Tuolumne River and Eleanor Creek.

Jan. 29, 1906—Board of Supervisors voted to abandon the Tuolumne project.

May 11, 1908—Garfield permit issued giving city rights of development of Eleanor or Hetch Hetchy.

Fall, 1908—First bond issue, $600,000, for land and water rights floated.

Jan., 1910—Second bond issue, $45,000,000, carried by vote of 20 to 1.

Feb. 25, 1910—Secretary Ballinger issued order for San Francisco to show cause why the Garfield permit should not be revoked.

July 15, 1912—Report of John R. Freeman filed after two years' study.

Dec., 1913—Baker Bill passed.

Spring, 1914—Road work begun.

July 8, 1914—First contract for construction road to Hetch Hetchy damsite awarded to the Utah Construction Company.

Dec. 6, 1915—Contract for Hetch Hetchy railroad awarded.

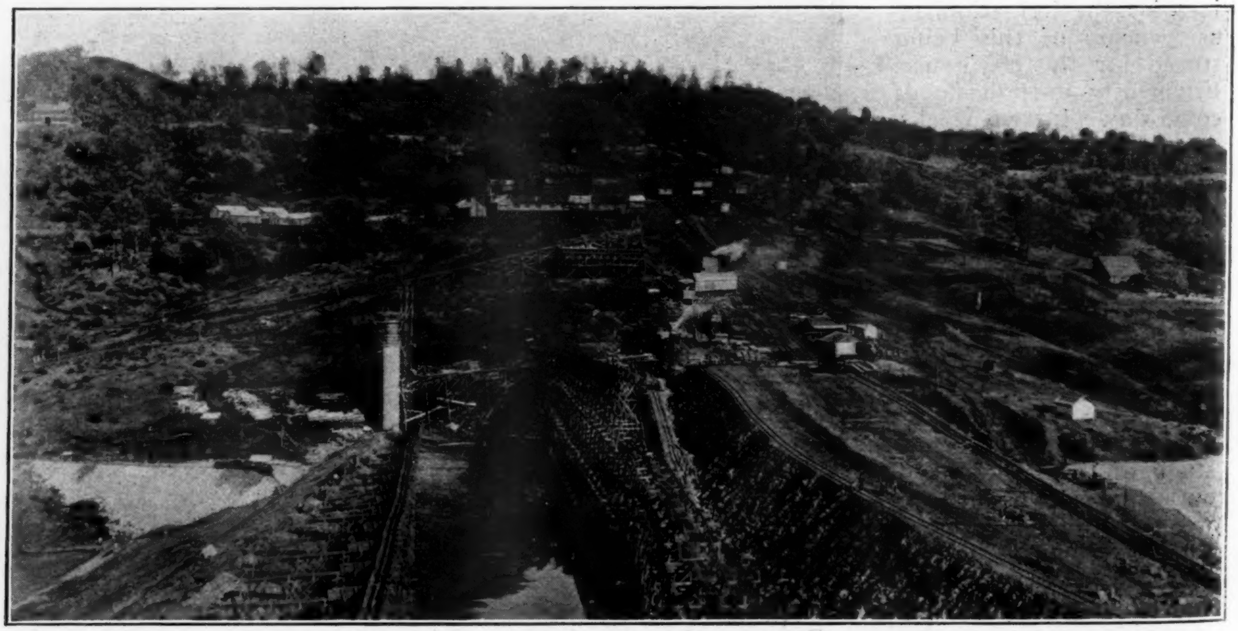
May, 1918—Early intake plant Lower Cherry Power development for construction purposes put into service.

Aug. 1, 1919—Contract for the construction of the Hetch Hetchy dam awarded to the Utah Construction Company.

Aug., 1921—Frames for foundations completed and pouring of concrete commenced.

March 23, 1923—Contract completed, conditional acceptance made.

July 7, 1923—Dedication of O'Shaughnessy dam.



PRIEST DAM UNDER CONSTRUCTION, DECEMBER, 1922.

PRIEST DAM

For several years the water from the dam will be permitted to flow down the natural stream bed a distance of twelve miles to Early Intake, to be there diverted, by means of a small arch dam, into a tunnel about 13 feet in diameter, 18½ miles long, which leads the water to Priest forebay reservoir.

The Priest dam is of the earth fill type and is said to be the third largest dam of that type in the country. Particular interest is attached to its construction owing to the fact that on one side of the core wall long trains of dirt-filled dump cars, operating over a long trestle, unload their contents while water washes the material toward the concrete core wall; the other side is being built up by the hydraulic method, making an impervious puddle core against the upstream side of the concrete core wall.

The concrete core wall extends the entire length of the dam from bed rock to top and is being built in sections, having horizontal joints every 16 feet and vertical joints every 50 feet. All joints are fitted with copper stops to prevent leakage. When completed, the dam will be 1,000 feet long and 145 feet high.

Priest forebay reservoir holds about 2½ days flow of the conduit, and from this reservoir a tunnel 6,000 feet long is built through a spur of the mountain and connected by large pipes to Moccasin Creek power house, which is 300 feet long, built of steel and concrete.

The Moccasin Creek power plant will have a 24-hour average capacity of 52,500 k.w. It is estimated that a revenue of from $1,500,000 to $2,000,000 yearly will be obtained from this power. The revenue will assist the city of San Francisco in financing the remainder of the Hetch Hetchy project, and the energy developed will be a valuable addition to the power resources of California.

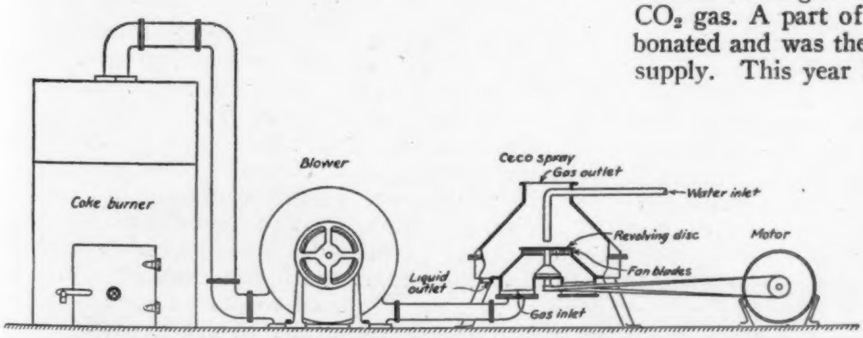
Water Purification in Columbus

The report of the Water Softening and Purification Works of Columbus, Ohio, for the year 1922 contains a description by Charles P. Hoover, the chemist in charge, of some of the studies and experiments made during the year of more than usual interest. One set of studies discloses that temperature is a far greater factor than time in completing the chemical reactions and its effect is more pronounced in water having a hardness of more than 400 parts of 1,000,000 than where the hardness is less than 300 parts. At higher temperature less calcium and magnesium remain in solution than at lower temperatures. At high temperatures the reaction between the lime and the soda ash and the calcium and magnesium salts results in a more crystalline and less soluble precipitate than at low temperatures. As the temperature lowers, more and more soluble and colloidal is the precipitate formed.

Results at Columbus from 12,000 determinations during the past eleven years indicate that the period of reaction between the softening chemicals and the calcium and magnesium salts is short, 90 per cent. of the reaction taking place in the mixing tanks, only 3 per cent. in the fifteen hours while passing through the settling basins, and 7 per cent. while passing through the filters. This indicates that large settling basins are not so necessary for water softening as has always been supposed. Apparently the colloidal precipitates crystallize in passing through the settling basins and are thus removed, but this is not where the chemical reactions take place. Mr. Hoover believes that the filters would have removed the 3 per cent. lost in the settling basins in addition to removing 7 per cent. of the hardness.

At this plant the softening chemicals are added to about 25 per cent. of the water and this overdosed portion is then mixed with the remaining 75 per cent. after which the mixture passes slowly through baffled mixing tanks. The large flocs already formed serve as a nucleus upon which the newly-formed precipitates can build, and as the water rolls over and under the baffles, the floc seems to grow in size and by the time the water reaches the settling basins it is so well coagulated that sedimentation takes place almost instantaneously.

Another line of experiments was in connection with adding CO_2 gas for carbonating the softened water. The first experimental plant consisted of CO_2 gas in cylinders applied to the water by means of a chlorinator. The second plant consisted of a burner for burning coke, and a blower which sucks the gases from the burning coke and forces them into an absorber, where the gas enters at the bottoms and water is fed in at the top. The water drips on to a disc which revolves at the rate of 1800 revolutions per minute and the gas, meeting this film of water, is absorbed by it. The carbonated water discharged from this absorber during a few of the tests contained as high as 600 to 700 parts per 1,000,000 of CO_2 gas. A part of the water was thus highly carbonated and was then mixed with the balance of the supply. This year Mr. Hoover is expecting to test the use of a carbonator used by soft drink bottling plants which produces an effluent showing 24 pounds of CO_2 in 500 gallons. Theoretically a plant which, including a 2-horsepower motor, would cost about $900, should produce enough CO_2 to carbonate 2,000,000 gallons of water.



EXPERIMENTAL CARBONATOR PLANT AT COLUMBUS WATER SOFTENING WORKS.

Recent Legal Decisions

LAND DEDICATED FOR STREET CANNOT BE LEASED FOR PRIVATE USE

The Pennsylvania Supreme Court holds Armsby Land Co. v. City of Pittsburg, 119 Atl. 730, that where land is dedicated for street purposes by the owner and accepted by the municipality, such action is equivalent to a taking, and the property so taken may not lawfully be applied to another and distinct purpose by the municipality unless it be a public use not inconsistent with its use as a highway. It cannot be leased by the city to a corporation or individual engaged in commercial or other pursuits, for private use.

AUTHORITY TO CONSTRUCT SYSTEM OF ROADS NOT AVAILABLE FOR CONSTRUCTION OF PART ONLY

The Indiana Appelate Court holds, Wilson v. Board of Commissioners, 137 N. E. 783, that where a petition for the construction of roads stated that they were so connected as to form one system and prayed that they be voted on as one road, and the taxpayers voted on the system as a whole, the election authorizing the board to construct the system as one road did not give it authority to construct any one or more of the roads less than the whole.

PAVING IMPROVEMENT CONTRACT, DELAYED FOR THREE YEARS WITH CITY'S CONSENT, NOT ABANDONED

The South Dakota Supreme Court holds, Eckhart v. C. H. Atkinson Paving Co., 191 N. W. 441, a suit to restrain the making of a street improvement to be paid for by local assessment, that a contract for a municipal improvement which has been delayed, with the consent of the city, for three years owing to an obstruction of the street, was not abandoned; and the injunction was denied, it not being shown that the work could be done any cheaper now than it could have been done three years ago, or for any less than the amount specified in the contract.

ROAD CONTRACTOR NOT BOUND TO PROCEED WITH CONTRACT WHERE NO STEPS TAKEN TO MEET INSTALLMENTS AS THEY BECOME DUE

When a road district has issued and sold bonds and received the proceeds, and a contract has been let to a road contractor to construct highways in the district, and the contractor has proceeded with the work of construction to the point where all the proceeds of the bonds have been exhausted in payment to him on such contract in monthly installments on estimates of the engineer in charge, as provided by the contract, and the work has not been completed, and the county has taken no steps to issue additional bonds or otherwise provide for meeting the monthly installments as they become due to the contractor, the Mississippi Supreme Court holds, Marshall County v. Callaghan, 94 So. 5, that the contractor is justified in refusing to proceed further with the work.

Where the county sues the road contractor on said contract for damages for a breach thereof in failing to proceed with the construction of the public highways contracted to be built, the county is not entitled to recover unless it alleges and proves that it either had funds in the treasury to meet the contractor's monthly installments, or that it had taken steps by which it would certainly realize such funds.

CONTRACT FOR PLANS AND SPECIFICATIONS OF WATERWORKS CONTINGENT ON STATUTORY REQUIREMENTS

An engineer made a contract with a city agreeing to make the plans and specifications for a waterworks plant and superintend its construction for a percentage of the cost, to be paid from the fund created for the improvement. Although the initial steps were taken by the city council to proceed with the improvement, the assent of property owners necessary under the state statute, was not obtained, and no fund was created. The Circuit Court of Appeals, Eighth Circuit, holds, Cory & Le Cocq v. City of Hankinson, N. D., 284 Fed. 327, that the contract imposed no liability on the city for work done thereunder in making the plans, the plaintiff being aware when the contract was made of the necessity for the owners' consent to the improvement.

TOWN NOT BOUND TO INTERFERE WITH CONTRACTOR TO PROTECT SURETY

The Louisiana Supreme Court holds, Town of Mandeville v. Paquette, 95 So. 391, that the failure of the contractor contracting with a town for the construction of a sea wall to carry storm insurance as agreed did not release the contractor's surety on the contractor's default. The contract contained no provision as to the backfilling keeping pace with the setting of piling and putting on of the coping. It is held that the town owed the surety no duty to interfere and see that the contractor did not leave a long row of pilings unprotected by backfilling and exposed to damage by storms.

BUILDING PERMITS—ORDINANCE AS TO FIRE LIMITS

The city council of Seattle, under section 18 of the city charter, providing that "the city council shall have the power by ordinance to establish fire limits . . . to prohibit the erection within such fire limits of any building . . . and to provide for the removal of any building erected contrary to such prohibition," authorized, by ordinance, the superintendent of buildings to require any building to be removed or demolished when it should be found to be erected in violation of the prescribed fire limits. A building permit was issued, under a mistake of fact, in violation of this ordinance. The Washington Supreme Court holds, Nolan v. Blackwell, 212 Pac. 1048, that the permit conferred no rights to occupancy even though completion of the building was permitted. The ordinance was a sufficient compliance with the charter, and the council was not required to pass a special ordinance to check violations of its general ordinance on the subject.